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### A REVISION OF THE GENUS KOELREUTERIA (SAPINDACEAE)

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IN HIS REVISION, published posthumously in *Das Pflanzenreich* (1933), L. Radlkofer recognized seven species of *Koelreuteria* Laxmann, all from eastern Asia. Among the 143 genera and 14 tribes of Sapindaceae delimited by Radlkofer, the tribe Koelreuterieae consists of *Koelreuteria*, *Stocksia*, and *Erythrophysa*, all of the Old World (Radlkofer, 1931). Its immediate relationships are with tribe Cupanieae (45 genera), tribe Cosignieae (two genera), and tribe Dodonaeae (14 genera).

Radlkofer was the acknowledged world authority on the Sapindaceae, and his monumental world monograph of the family (1931–1934) is still the standard reference. While the treatment of *Koelreuteria* reflects the author's characteristic scholarly resumé of the literature and related historic details, the taxonomic portion suffers from a rather limited understanding of relationships and variation within the group, due, no doubt, to a paucity of available material for comparison. In the writer's view, too many taxa were recognized at the species level, causing problems in the application of names to these trees both in the herbarium and in cultivation. Two members of the genus, *K. bipinnata* (syn. *K. integrifoliola*) and *K. elegans* (syn. *K. henryi*, *K. formosana*) have been the source of most of the taxonomic confusion existing among botanists, horticulturists, and others who have dealt with these trees in the past. The third member, *K. paniculata*, is much less troublesome taxonomically. All of the known species of *Koelreuteria* are trees of widely recognized horticultural merit; they are found in parks, arboreta, campuses, nurseries, and gardens of this country and of many other countries as well. A critical review of the genus, therefore, has been undertaken to update the taxonomy of the group, especially with reference to the cultivated members.

Since Radlkofer's day, a vast quantity of new material has become available, and the known distribution of the genus has been extended from Taiwan to Fiji, some 7200 km. to the southeast. As currently recognized, the genus *Koelreuteria* consists of three entities at the species level, *K. paniculata* and *K. bipinnata*, both confined to China, and *K. elegans*, distributed in Taiwan and Fiji. Evidence now shows conclusively



that *K. paniculata* is not indigenous to Korea and Japan, as hitherto recorded by some authors, but occurs in those areas only as a naturalized introduction dating from an earlier period in history.

The plant described as *Koelreuteria minor* Hemsley (1900) has been removed from the genus *Koelreuteria*. It will be treated separately as a proposed new genus on the basis of distinctive floral characters which heretofore have not been recognized.

This account is based on material borrowed from 35 herbaria, as well as on personal observations of living material of all the taxa presently in cultivation.

## HISTORY

The genus *Koelreuteria* dates from 1772 and was based on cultivated material grown at St. Petersburg (now Leningrad). Earlier, during his 14-year sojourn in north China, the Jesuit father Pierre d'Incarville (1706–1757) sent seeds of many different plants to a Professor Krasheninnikov, academician botanist at St. Petersburg, and to Bernard de Jussieu in Paris. He also made the first herbarium collection of north Chinese plants, which is still preserved in the Muséum National d'Histoire Naturelle in Paris. In addition to seeds of *K. paniculata*, D'Incarville also sent seeds of a number of woody plants previously unknown in Europe, including *Ailanthus altissima*, *Biota orientalis*, *Caragana chamlagu*, *Gleditsia sinensis*, *Lycium chinense*, *Vitex negundo*, and *Zizyphus jujube* (Bretschneider, 1881).

The tree now called *Koelreuteria* was first observed by Erik Laxmann (1737–1796)<sup>1</sup> growing in the winter gardens of the Academy in St. Petersburg, where it flowered for the first time in the warm summer of 1771. Laxmann, in his admiration for the plant, sent a leaf and a brief Latin description of the tree to Linnaeus in a letter dated August 5, 1771; the letter is still preserved in the Linnean Society in London. Laxmann's enthusiasm was later transmitted in *Novi Commentarii Academiae Scientiarum Imperialis Petropolitanae* 16: 561. 1772, the publication in which the name *Koelreuteria* appears for the first time. His introductory comments are as follows (from the Latin):

“Although for 20 years and more this little tree has flourished in the winter gardens of the Academy, yet no one could classify it exactly, lacking any fruiting all these years. The earlier part of the past summer [1771], I mean the months of May and June, which were quite

<sup>1</sup> Laxmann, of Finnish birth, attended botanical lectures by Pehr Kalm, famed pupil of Linnaeus and botanical traveler in North America, at the University of Åbo (now Turku) in Finland. In 1762 he moved to St. Petersburg; he later made extensive travels across Siberia and once visited Alaska, then a Russian province. He corresponded with Linnaeus between 1764 and 1776 and published 5 botanical papers, in addition to pursuing his other interests in mineralogy, chemistry, travel, and entomology. He died during the middle of a Siberian winter in 1796 on his way to Japan (cf. Raskin & Shaffranovskii, 1971).



moist, were so favorable to flowering that the *Arachis hypogaea*, and other plants native to the tropics, not only joyfully bloomed in the windows of my greenhouse, but even matured fruits. Also adorned with flowers was this little tree, whose nuptials our botanist had for so many years eagerly awaited. And so it was my fortune, to my exceeding delight, to be a spectator at these very rare nuptials. Having seen the flowers, I have taken care to depict from life this small tree, which constitutes its own genus. And in order to offer some small token of my esteem, and that of the world of plant lovers, to a man outstandingly and deservedly most distinguished, both in botany and in our botanic garden, Koelreuter,<sup>2</sup> I have named it *Koelreuteria*."

The genus has been treated by various authors. Jussieu (1789) was the first to associate *Koelreuteria* (misspelled "*Kolreuteria*") with the plant family "Sapindi"; De Candolle (1824) placed *Koelreuteria* among four genera of Sapindaceae, Tribe III, Dodonaeaceae H.B.K.; and Bentham and Hooker (1862) placed the genus among 89 genera in Suborder 1. Sapindeae of the Sapindaceae.

The taxonomic investigations of Sapindaceae by Radlkofer (who lived from 1829 to 1927), including revisions of all the genera, covered nearly half a century and are the most comprehensive ever undertaken of the family as a whole.

In his world monograph of the family in *Das Pflanzenreich* (1931-1934), Radlkofer placed *Koelreuteria* in his subfamily Dyssapindaceae (Sapindaceae anomospermae) in tribe Koelreuterieae Agardh (see Agardh, 1858) with two other genera, distinguishing between them as follows (from the German):

- A. Trees with large pinnate to bipinnate leaves with a naked rachis; flowers medium-sized, yellow; sepals valvate. . . . . *Koelreuteria* Laxm.
- A. Shrubs with small leaves; sepals imbricate.
  - B. Thorny shrubs with simple leaves, the membranous capsule 3-lobed. . . . . *Stocksia* Bentham.
  - B. Unarmed shrubs with pinnate leaves and a winged rachis, the utricelike membranous capsule ultimately irregularly dehiscent. . . . . *Erythrophysa* E. Meyer.

## MORPHOLOGY AND TAXONOMIC CRITERIA

**HABIT.** The genus *Koelreuteria* consists of medium-sized to large deciduous trees, usually with thick, rough to furrowed bark. Lenticels normally occur, especially on the twigs and young branches, although they are not diagnostic at the species level.

**VEGETATIVE SHOOTS.** Normally the terminal shoot bud remains permanently dormant. Growth usually emerges from axillary leaf buds below the

<sup>2</sup> Joseph Gottlieb Koelreuter (1733-1806) was a professor of natural history and director of the Margrave's gardens at the University of Karlsruhe. Koelreuter's fame rests as the first plant hybridist.



shoot apex. In *Koelreuteria paniculata*, for example, the dormant terminal vegetative buds may persist for several years, giving a characteristic knobby appearance to the twigs. The ontogeny of the two outer prophylls or bud scales of each axillary leaf bud may be compared with that of the lateral prophylls found in certain species of *Carya* (Stone, 1962).

LEAVES. The compound leaves are alternate and characteristically imparipinnate. Good taxonomic differences are exhibited in the leaves, and it is possible much of the time to distinguish the species on the basis of leaf differences.

INFLORESCENCES. Radlkofer (1933) referred to the ultimate flowering branches as "thyrsoides cincinnigeris," whereas Baillon (1878) referred to the same structures as "terminal ramosely cymiferous racemes." Modifications that resemble a cyme may occur, but basically the inflorescence of *Koelreuteria* is indeterminate and racemose and, in this respect, similar to some other sapindaceous genera, such as *Sapindus* and *Cupania*.

FLOWERS. (FIGURES 9, 12, 13.) Polygamy is the usual condition found in *Koelreuteria*. Normally, the flowers are functionally unisexual, both staminate and carpellate flowers occurring together in the same ultimate tertiary or quaternary branchlet. In the first flush of flowering, staminate flowers predominate in a ratio of approximately two staminate to one carpellate, although as flowering progresses carpellate flowers may predominate. Clos (1869) first observed that flowers of *Koelreuteria* produce stamens of two lengths, "les longistaminées," with functional stamens in wholly staminate flowers, and "les brevistaminées," with short erect and nonfunctional stamens in carpellate flowers. Although the anthers in carpellate flowers fail to develop properly and soon abort, further observation shows that the pollen grains are usually normal in size. As observed in *K. paniculata* and *K. elegans* subsp. *formosana*, the flowers are entomophilous, bees and other small insects being the usual pollinators.

At anthesis, the flowers of *Koelreuteria* are asymmetric, a condition derived through a shift of the petal and staminal whorls during growth. While in early bud stage both the petal and stamen whorls are regular and concentric, during development the petal limbs become reflexed in a posterior position and the staminal whorl becomes declinate through a shift in position of the filaments.

Petal shape in combination with other characters is of some diagnostic value in the identification of the taxa. Each petal consists of a claw (stalk) and limb with two accessory appendages. The appendages have been variously interpreted as "nectarium squama" (Laxmann, 1772), as "appendices glanduliformes" (Payer, 1857), as "bipartite scales" (Baillon, 1878, and Radlkofer, 1931), and as "glands" (Elwes & Henry, 1913). These accessory organs are, in fact, thickened lobulate-undulate outgrowths of the petal limb, whose function is undoubtedly the attraction of bees and other pollinating insects. In fresh, young, opening flowers of *Koelreuteria paniculata* and *K. elegans* subsp. *formosana*, for example,



the appendages appear uniformly yellow, the same color as the petal limb, while at anthesis, when various pollinators appear, the appendages turn a bright orange-red. Dr. Frank S. Santamour, research geneticist at the U. S. National Arboretum, has identified the red anthocyanin pigment in the appendages of *K. paniculata* as cyanidin 3-rutinoside, a fairly common pigment among flowering plants. The flowers, also, are quite fragrant in both species observed. Fresh flowers of *K. bipinnata* were not available for study.

Clos (1869) referred to the short raised stalk between the calyx and the disc as the androgynophore.

**FRUIT.** The dry, winglike papyraceous capsules provide an important means of identification, particularly in *Koelreuteria paniculata*, which has tapering conoidal capsules and is clearly distinguished from *K. bipinnata* and *K. elegans*, both with suborbicular to rotund capsules and morpho-

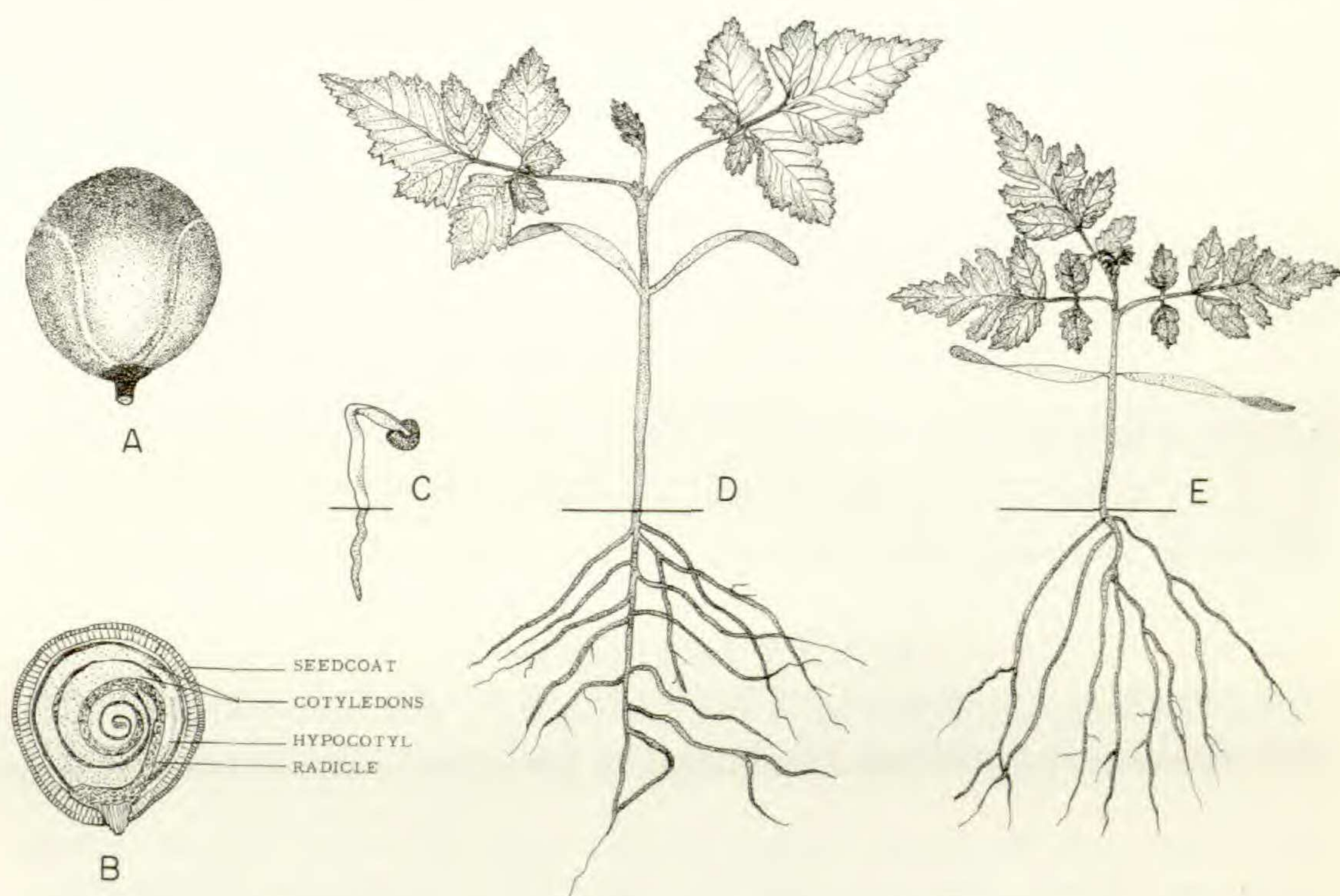


FIGURE 1. A-D, *Koelreuteria paniculata*: A, seed showing U-shaped outline of radicle on surface,  $\times 2\frac{1}{2}$ ; B, longitudinal section of seed, according to Rudolf (1974); C, germinating seed, first day,  $\times \frac{1}{3}$ ; D, first pair of true leaves already resemble the mature leaves,  $\times \frac{1}{3}$ . E, *K. bipinnata*, showing first true leaves still in juvenile condition,  $\times \frac{1}{3}$ .

logically very similar. In the past, too much emphasis has been placed on fruit characters, causing some of the confusion in the taxonomy of *Koelreuteria*. On the basis of fruit alone, Hemsley in 1900 described a plant as *K. minor*, with small retuse capsules, and Radlkofer (1933) followed a similar course in dealing with the same plant. Now that flowers are



available, it is clear that *K. minor* belongs not to the genus *Koelreuteria* at all, but to a new genus soon to be described.

**SEEDS AND SEEDLINGS.** (FIGURE 1.) The seeds are hard and smooth, with a bony seed coat, and they vary in size and shape from subspherical to pyriform. The persistent funiculus forms a short stipe at the base of the seed, which is diagnostic for the genus.

The seeds of *Koelreuteria* are difficult to germinate because of the bony seed coat. According to Rudolf (1974), dormancy and delayed seed germination may be overcome when the hard, impervious seeds are first soaked in sulfuric acid for one hour and then stratified in moist sand for 90 days at 41° F. (5° C.). Mechanical scarification also promotes fairly rapid germination. Seeds of *K. paniculata* may remain viable over a reasonably long period of time, with a 50 per cent germination recorded after ten years of storage in an unsealed glass jar.

The cotyledons in all of the species are strap-shaped. Of interest is the transition to mature leaves which takes place with the appearance of the first true leaves in *K. paniculata*. In *K. bipinnata* and *K. elegans* the first true leaves are strongly serrate, a condition of juvenility that persists during the early life of the plant before the mature leaves appear; data on the length of the transitional period, however, is lacking.

**CHROMOSOMES.** Darlington and Wylie (1955) reported a base number of  $x = 11$  for the sapindaceous genera *Cardiospermum* and *Koelreuteria*. Bowden (1945) reported a chromosome count of  $2n = 22$  for both *K. paniculata* and *K. elegans* subsp. *formosana* (*K. formosana*). A count of  $2n = 30$  for *K. paniculata* was reported by Eichhorn and Franquet (1936) but may be inaccurate.

#### POLLEN MORPHOLOGY

The following discussion of pollen morphology was contributed by Dr. Joan Nowicke, palynologist, Smithsonian Institution, Washington, D. C.

**MATERIALS AND METHODS.** Pollen samples were removed from herbarium specimens, acetolyzed according to the method outlined by Erdtman (1966), and mounted in glycerin jelly. All slides are deposited at the Pollen Laboratory, Department of Botany, Smithsonian Institution. Measurements are based on only 10 grains and should, therefore, be treated with reservation. Material for the scanning electron microscope was acetolyzed and mounted in a mixture of alcohol-water. After evaporation, the grains were vacuum-coated with gold, examined, and photographed with a Cambridge Stereoscan MK II A microscope.

**GENERIC DESCRIPTION OF POLLEN.** Grains single, spheroidal, oblate-spheroidal or rarely prolate-spheroidal, 20–27  $\mu\text{m}$ .  $P \times 21\text{--}27 \mu\text{m}$ . E, the amb (polar view) triangular, 3-colporate, the apertures at the angles (angulaperturate), the exine ca. 1.5–2  $\mu\text{m}$ . thick (measured at the poles),



the ektexine finely striate, the striae parallel or irregular and finely striate-reticulate. (FIGURES 2-7.)

The pollen grains of the four taxa examined were very similar and, with the exception of *K. elegans* subsp. *elegans* from Fiji, almost identical. Descriptions of pollen are given below for three species: *K. paniculata* Laxm., *K. bipinnata* Franchet, and *K. elegans* (Seem.) A. C. Sm.

***Koelreuteria paniculata* Laxm.**

FIGURES 2, 3.

Grains subprolate to spheroidal, 25-27  $\mu\text{m}$ .  $P \times 21 \mu\text{m}$ . E, the exine ca. 1.5-2  $\mu\text{m}$ ., the ektexine striate.

MATERIAL EXAMINED. **China.** Litang valley, Muli Dist. [28.20N, 100.48E], 10000-11000 ft. alt., *Forrest 21330* (US).

***Koelreuteria bipinnata* Franchet.**

FIGURES 4, 5.

Grains oblate-spheroidal, 22-23(-26)  $\mu\text{m}$ .  $P \times 23-27 \mu\text{m}$ . E, the exine ca. 2  $\mu\text{m}$ ., the ektexine finely striate.

MATERIAL EXAMINED. **China.** Ta-long-tan, près Tapin-tze, 21 juillet 1886, *Delavay s.n.* (P).

***Koelreuteria elegans* (Seem.) A. C. Sm. subsp. *elegans*.** FIGURES 6, 7.

Grains mostly spheroidal, 24-26  $\mu\text{m}$ .  $P \times 24-26 \mu\text{m}$ . E, the exine ca. 1.5  $\mu\text{m}$ ., the ektexine finely striate-reticulate.

MATERIAL EXAMINED. **Fiji.** Nadroga & Novosa, Nabosewale, vicinity of Nadrau, (*Ranamu*) *Fiji Dept. For. 1171* (SUVA).

This is the most distinctive pollen of the four taxa examined because of the irregularly striate ektexine.

***Koelreuteria elegans* subsp. *formosana* (Hayata) F. G. Meyer.**

Grains mostly spheroidal, 20-23  $\mu\text{m}$ .  $P \times 21-23 \mu\text{m}$ . E, the exine ca. 1.5  $\mu\text{m}$ ., the ektexine striate.

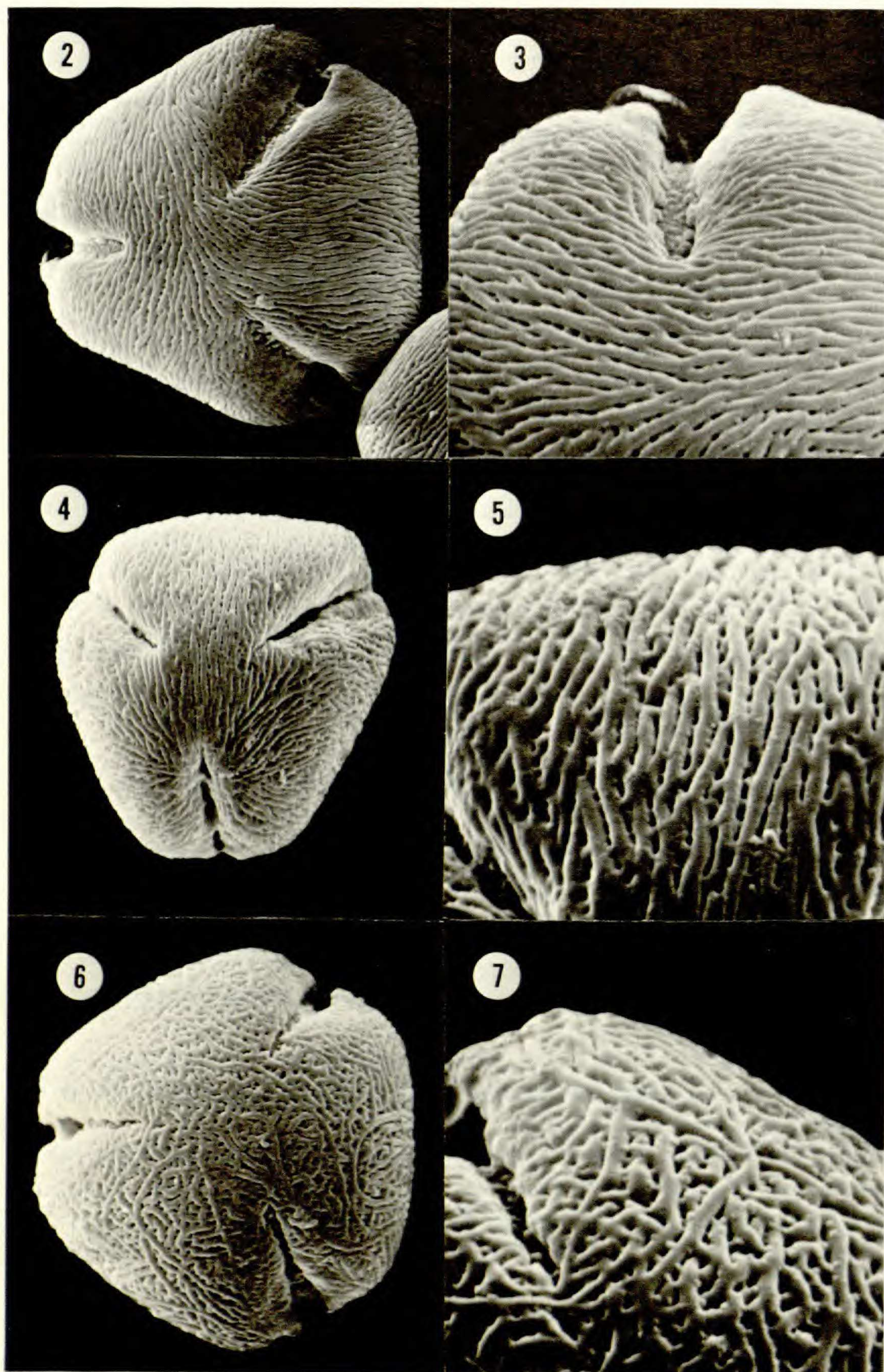
MATERIAL EXAMINED. **Taiwan.** Cuntin Hunchuen, *Keng s.n.* (US).

This subspecies is very similar to *K. bipinnata*.

#### ACKNOWLEDGMENTS

I should like to thank the curators of all 35 herbaria for the loan of valuable herbarium material which made the present study possible. In addition, many individuals have given inspiration and encouragement. Initially, John M. Fogg, Jr., and the late Sigmond L. Solymosy pointed out the need for a thorough study of the cultivated members of the genus *Koelreuteria*. I am also indebted to the following persons for specimens and for the variety of ways in which they were helpful: Dr. Le-min Chang,





FIGURES 2-7. Scanning Electron Micrographs of *Koelreuteria* pollen: 2, *K. paniculata*, polar view,  $\times$  ca. 2035; 3, *K. paniculata*, enlargement of surface



Dr. Francis Ching, Dr. John R. Creech, Mr. Leonid Enari, Mrs. Bruce English, Prof. Joseph Ewan, Dr. Charles R. Gunn, Dr. Hiroshi Hara, Dr. Shiu-ying Hu, Dr. Hiroo Kanai, Ms. N. Khan, Dr. Yong No Lee, Mr. William U. Massey, Dr. Katherine K. Muller, Mr. John Popenoe, The Earl of Rosse, Dr. Frank S. Santamour, Mr. Paul W. Soderholm, Mrs. S. Swatibau, Professor Vivi Täckholm, and Ms. Saula Vodonaivalu. For translations I am indebted to Mrs. Elaine Mathers (Latin), Dr. Elmer E. Leppik (Russian), and Mrs. Evelyn Chen (Chinese). Mr. T. O'Grady, Secretary of the Linnean Society, London, sent valuable manuscript data, and I am equally indebted to Dr. W. T. Stearn of the British Museum (Natural History) for supplying details from the Laxmann correspondence in the Linnean Society. Dr. Joan Nowicke has kindly contributed the details on the pollen and furnished the scanning electron microscope photographs. Finally, I am greatly indebted to my wife Lillian for her continued encouragement and for the drawings that embellish these pages.

### TAXONOMIC TREATMENT<sup>3</sup>

**Koelreuteria**<sup>4</sup> Laxm. in Nov. Comm. Acad. Sci. Imp. Petrop. 16: 561–564. *t.* 18. 1772; Radlkofer in Engler, Pflanzenr. IV. 165: 1329. 1933. TYPE SPECIES: *K. paniculata* Laxm.

*Sapindus* L. *sensu* Murray, Linn. Syst. Veg. (ed. 13.) 315. 1774. Includes *S. chinensis* Murray (*nomen illegit.*), a substitute name for *K. paniculata* Laxm.

Deciduous trees, single or sometimes multitrunked, with gray to brown, thick, sometimes fissured bark; twigs, young branches, and petioles often prominently lenticellate; pith whitish to light brown; axillary bud scales (prophylls) 2, glabrous without, strongly sericeous within. Leaves alternate, exstipulate, imparipinnate, sometimes pinnatisect, the petioles pul-

<sup>3</sup> The localities, pinpointed on dot maps (FIGURES 11, 14, 16), are in accordance with standard gazetteers and atlases, as follows. **China:** *Mainland China, Gazetteer No. 22.* ed. 2. Vols. 1 & 2. Prepared by the Geographic Names Division, Army Map Service, Washington, D. C. 1968; *The Times Atlas of the World.* Vol. 1. The Times Publishing Co. Ltd., London. 1958. **Taiwan:** *Republic of China, Official Standard Names Gazetteer.* United States Board on Geographic Names, Defense Mapping Agency Topographic Center, Washington, D. C. 1974. **Fiji:** *Fiji, Tonga, and Nauru, Official Standard Names Gazetteer.* United States Board on Geographic Names, Defense Mapping Agency Topographic Center, Washington, D. C. 1974.

Herbarium acronyms are in accordance with those of Holmgren and Keuken (1974). The abbreviation KFI (Korea Forest Institute) is the only symbol not cited by Holmgren and Keuken. Where possible, coordinates have been added in brackets to pinpoint localities.

<sup>4</sup> Orthographic variants are *Kölreutera*, *Kolreuteria*, and *Koelreutera*, all occurring after 1772.

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detail and colpus edge,  $\times$  5900; 4, *K. bipinnata*, polar view,  $\times$  1976; 5, *K. bipinnata*, enlargement of surface detail, edge of colpus at lower left,  $\times$  5900; 6, *K. elegans* subsp. *elegans* (Fiji), polar view,  $\times$  2183; 7, *K. elegans* subsp. *elegans*, enlargement of surface detail, colpus at left,  $\times$  5900.



vinate at base, the rachis canaliculate or flattened on upper side, glabrous or densely short-hairy on the middle portion, terete beneath; leaflets usually alternate, sometimes opposite, elliptic to ovate, flat, usually more or less oblique, entire or serrate to crenate, sometimes pinnatisect to lobed, sessile or short-petiolulate, sometimes decurrent on the rachis, thick membranous to subcoriaceous, dull or sometimes lustrous, glabrous to sparsely



FIGURE 8. *Koelreuteria paniculata* (Meyer 12570, cultivated): habit and mature capsules,  $\times \frac{1}{4}$ .



pubescent, sometimes glandular on the veins, mainly beneath, the median leaflets usually largest. Inflorescence terminal, paniculate, pyramidal, loosely branched; flowers polygamous, both the staminate and carpellate on the ultimate tertiary or quaternary branchlets, bracteate, acropetal, racemose, manifestly regular at first, becoming asymmetric, pedicellate; calyx lobes 5, 3 long and 2 short, valvate, ovate, ciliate-glandular or puberulent, often persistent; disc slightly oblique, lobulate, on a short androgynophore, more or less undulate-lobed and depressed; petals 4–5 (6), unguiculate, inserted at the base of the androgynophore, claw up to twice as long as the calyx lobes, strongly villous, limb glabrous, strongly reflexed, appendages simple to compound, folded and undulate, yellow at first, changing to orange-red at anthesis; stamens usually 8 (9), rarely fewer, on a raised, slightly oblique disc, filaments with long straight hairs mostly on the lower half, declinate at anthesis; anthers antrorse, with short straight evanescent hairs on the face and margins; pollen grains 3-colporate. Ovary on the disc, 3-locular, placentation parietal; ovules usually 6, 2 in each locule, more or less median, anatropous, 3 descending and the raphe dorsal, 3 ascending and the raphe ventral; style exerted, stigmas 3. Capsules triangular in cross-section, connate near base, inflated in upper portion, conoidal or ellipsoidal, sparsely hairy at first, becoming glabrous, loculicidal, the valves winglike, papyraceous, reticulate-veined, ovate and tapered or rotund to suborbicular. Seeds subspherical to pyriform, black or brown, shiny, sometimes partially or entirely covered with a whitish waxlike coating, bony, with an exalbuminous, spirally convolute embryo, the funiculus persistent, forming a short stipe; seedlings epigeal, with narrow, strap-shaped cotyledons; base chromosome number 11.

VERNACULAR NAMES. The commonest English name for *Koelreuteria* is goldenrain-tree. The name *Luan Shu* is applied in China, although many other names are used on a regional basis (Chen, 1957): *Shih Luan Shu*, rock Luan tree (Chekiang); *Hei Yeh Shu*, black-leaf tree, and *Mu Lan Ya*, teeth of wooden railing (Honan); *Hei Se Yeh Shu*, black-leaf tree (Hopeh); *Shan Ch'a Yeh*, mountain-tea leaves (northeast region); *Yuan P'ang*, soft stick (Shantung); *Luan Hua* (from an old Chinese book on plants); *Mu Luan*, woody Luan (from a Chinese materia medica for famine relief).

#### KEY TO THE SPECIES

- A. Leaves pinnate, rarely bipinnate; leaflets coarsely crenate-serrate to pinnatisect and lobulate, abruptly to narrowly acuminate, often apiculate; valves of capsule ovate, tapering to apex, greenish to tawny while young, dark lustrous brown when mature. China. Naturalized in Korea and Japan. . . . . 1. *K. paniculata*.
- A. Leaves bipinnate; leaflets entire to shallowly serrate, tapering at tip, usually not apiculate; valves of capsule rotund to suborbicular, rose-purple while young, brown to tawny at maturity.
- B. Leaflets weakly oblique, acute to short-acuminate, entire or uniformly



serrate (the lower leaflets never pinnatisect); petals 4, rarely 5; calyx lobes fimbriate-glandular; capsule with valves 3.7–6.6 cm. long, 3–5 cm. wide. Southern to southwestern China. . . . . 2. *K. bipinnata*.

- B. Leaflets strongly oblique, long-acuminate to sometimes caudate, entire or irregularly crenate-serrate (the lower leaflets occasionally pinnatisect); petals commonly 5 or 4, rarely 6; calyx lobes ciliate-glandular, with short-clavate, often amber-colored to reddish glands; capsule with valves 3.4–5(–6) cm. long, (2.5–)3.1–4.6 cm. wide. Taiwan, Fiji. . . 3. *K. elegans*.

1. ***Koelreuteria paniculata*** Laxm. in Nov. Comm. Acad. Sci. Imp. Petrop. 16: 561–564. *t.* 18. 1772; Aiton, Hort. Kew. 2: 7. 1789; Mirbel in Duhamel, Traité des arbres et arbustes (ed. 2) 1: 165. *t.* 36. 1801; Martyn, Miller Gard. Bot. Dict. (ed. 9) 2: *n.* 1. 1807; Rees, Cyclop. 20: I. pt. 39. 1812; Bunge in Mem. Div. Sav. Acad. Sci. St. Petersburg 2: 85. 1835; Sieb. & Zucc. in Abh. Bayer. Acad. 4(2): 153. 1845; Forbes & Hemsley in Jour. Linn. Soc. Bot. 23: 138. 1886; Elwes & Henry, Trees Gr. Brit. & Ireland 7: 1932, 1933. 1913; Radlk. in Engler, Pflanzenr. IV. 165: 1330. 1933; How & Ho in Acta Phytotax. Sinica 3: 405. 1955. LECTOTYPE: *Laxmann s.n.* (LINN, No. 514.5; ICC Micro. ed. hb. LINN, card 268).  
FIGURES 1–3, 8, 9, 11.

*Sapindus chinensis* Murray, Linn. Syst. Veg. (ed. 13) 315. 1774; Linn. f. Suppl. Pl. (ed. 2) 228. 1781; Murray, *Ibid.* (ed. 14) 380. 1784; Murray, *Ibid.* (ed. 15) emend. Persoon, 407. 1797; Murray, *Ibid.* (ed. 15) 311. 1798; Poiret in Lamarck, Encycl. Méth. Bot. 6(2): 667. 1805 (*nomen illegit.*). A substitute name for *K. paniculata* Laxm.

*Sapindus sinensis* J. F. Gmelin, Linn. Syst. Nat. (ed. 13) 2: 642. 1791; Linn. Syst. Veg. 1: 642. 1796, reprinted from ed. 13. 1791 (an orthographic variant based on *Sapindus chinensis* Murray).

*Koelreuteria chinensis* (Murray) Hoffmannsegg, Verzeich. Pflanzenkult. 70. 1824, *pro syn.*

*Koelreuteria paullinioides* L'Hérit. Sert. Angl. 11. 1789; *Ibid.* pl. 19. 1792, mislabeled *K. paniculata*. Type specimen not seen.

*Koelreuteria japonica* Hassk. Cat. Hort. Bog. Alt. 226. 1844, *nomen nudum*.

*Koelreuteria paniculata*  $\beta$  var. *japonica* Siebold in Jaarb. Kon. Nederld. Maatsch, Aanmoed. Tuinbouw. 31. 1844, *pro syn.*

*Koelreuteria apiculata* Rehder & Wilson in Sarg. Pl. Wilson. 2: 191. 1914; Chung in Mem. Sci. Soc. China 1: 152. 1924; Radlk. in Engler, Pflanzenr. IV. 165: 1333. 1933; Rehder, Man. 584. 1934; Lee, For. Bot. China 789. 1935. LECTOTYPE: *Wilson 2370b* (A); isoelectotype (us), fruit. Collected September, 1908. It is necessary to select a lectotype specimen to separate flowering and fruiting specimens, collected on different dates and originally assigned the same field number, *Wilson 2370*.

*Koelreuteria paniculata* var. *apiculata* (Rehder & Wilson) Rehder in Jour. Arnold Arb. 20: 418. 1939; Chun in Sunyatsenia 4: 239. 1940; Rehder, Man. (ed. 2) 592. 1940; *Ibid.* Bibl. 434. 1949.

*Koelreuteria bipinnata* Franchet var. *apiculata* (Rehder & Wilson) How & Ho in Acta Phytotax. Sinica 3: 407. 1955. Based on *Wilson 2370* = *K. paniculata* Laxm.



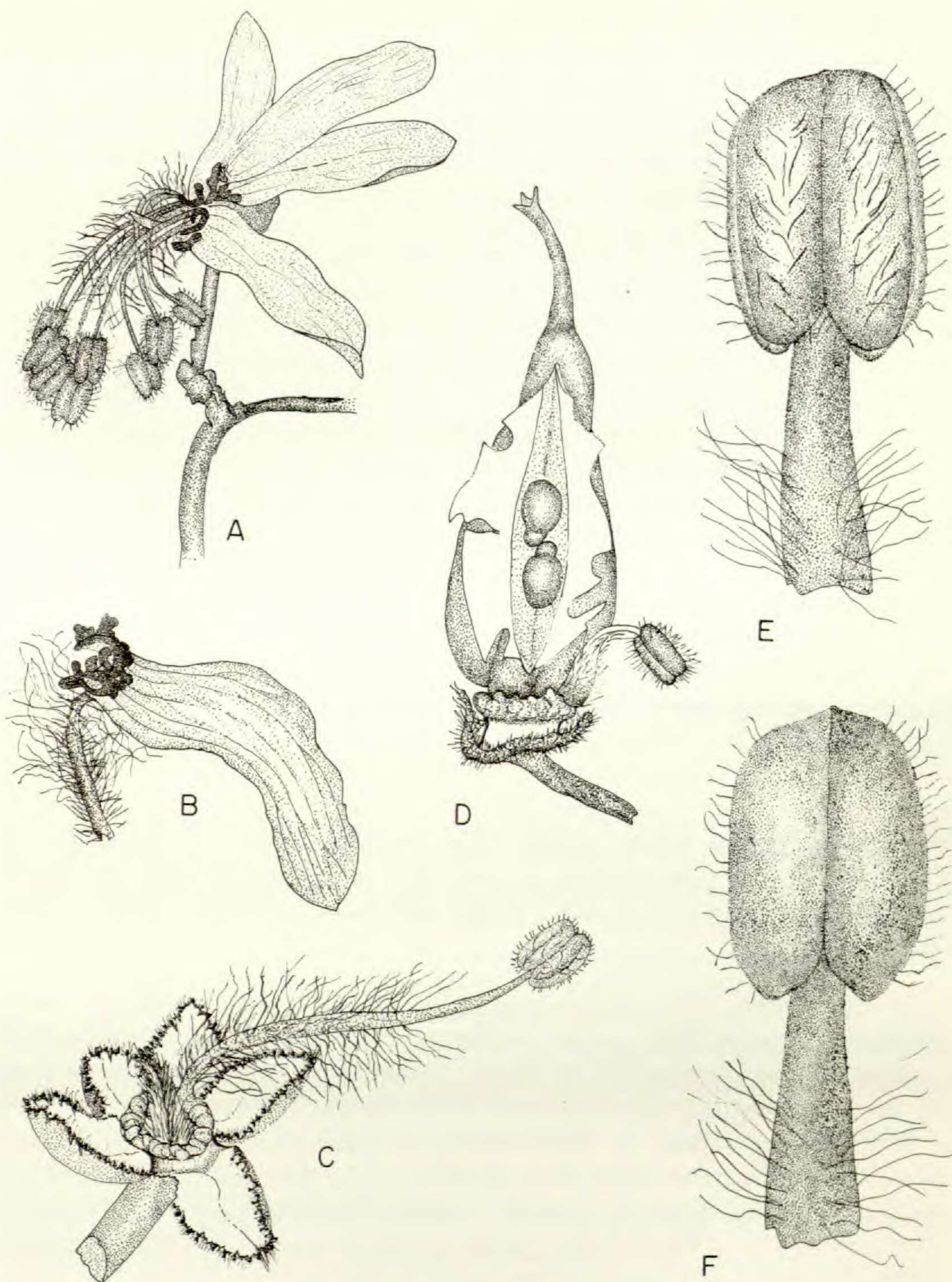


FIGURE 9. *Koelreuteria paniculata*: A, staminate flower,  $\times 6$ ; B, corolla lobe, showing villous claw and limb with basal appendages,  $\times 12$ ; C, staminate flower, showing erose-glandular calyx lobes, raised disc, abortive ovary, and stamen with antrorse anther immediately before anthesis,  $\times 6$ ; D, young capsule shortly after anthesis, torn open to show position of seeds, one descending and the raphe dorsal, in the adjacent valve ascending and the raphe ventral,  $\times 6$ ; E, stamen, ventral view, setulose on antrorse face and on margins on dorsal side; filaments villous in lower portion,  $\times 14$ ; F, stamen, dorsal view, setulose only on the margins,  $\times 14$ .



Tree to ca. 13 m. in height and to ca. 50 cm. in diameter; bark thick, gray-black, longitudinally furrowed; lenticels gray to dark brown, small, not very prominent; twigs glabrous or sometimes puberulent below the inflorescence. Leaves spreading, pinnate or rarely bipinnate, 25–50 cm. long, 10–25 cm. wide; rachis usually glabrous on lower side, with scattered hairs on upper side; leaflets 11–18, cuneate to truncate, only barely unequal at base, narrowly to broadly ovate to elliptic, 4.8–10.7 cm. long, 2.8–6.9 cm. wide, coarsely crenate-serrate to pinnatisect and lobulate, abruptly to narrowly acuminate, often apiculate at tip, veins faint above, slightly raised beneath, usually with scattered very short crispate hairs on the midvein above, the hairs beneath longer and in tufts along the midvein, sometimes mixed with scattered glands, margins sometimes ciliate; petiolules very short, 1–2 mm. long, often densely hairy. Inflorescence 25–30 cm. long, as much across, densely puberulent, especially on the ultimate branchlets, and with scattered glands. Flowers slightly fragrant; pedicels 2.5–5 mm. long; calyx lobes erose-glandular on margin, glabrous on back or glandular-hairy; petals 4, limb 4.5–7 mm. long, 1.5–2 mm. wide, acute, primrose yellow (4A, Royal Horticultural Society Colour Chart, London, 1966), appendages with few folds, primrose yellow at first, changing to orange-red (34A, *Ibid.*) at anthesis, claw 1–2.5 mm. long, densely villous with ascending hairs, and partly orange-red; stamens long-exserted, filaments densely villous with spreading straight hairs, especially in the lower half and at base, anthers lavender. Capsules conoidal, the valves ovate (placenta protruding as a winglike projection from each valve), tapering to apex, apiculate, 4.3–6.9 cm. long, 2.5–3.2 cm. wide, greenish to tawny while young, dark lustrous brown at maturity, reticulate-veined on the outside, smooth and somewhat lustrous on the inside; styles 3–5 mm. long; seeds nearly spherical, 6–7 mm.  $\times$  6.5–8 mm., black;  $2n = 22$ .

DISTRIBUTION. China, from Liaoning Province in the northeast, southwestward through the central provinces to Yunnan; also cultivated in gardens. Although reported by Chun (1940) from Kweichow and Kwangsi, the specimens actually represent *Koelreuteria bipinnata*.

Flowering mid-June to mid-August; fruiting August and September. Mature capsules with seeds may persist on the tree well into winter and even to the next flowering season. Various habitats have been recorded: river courses, open forest areas, rocky mountain slopes, and valleys mainly in well-drained soils from near sea level to 300 m.

REPRESENTATIVE SPECIMENS. China. ANHWEI: Chuchow [33.19N, 118.18E], *Tsu* 529 (UC). CHEKIANG: locality undesignated, *Barchet s.n.* (MO). HONAN: near Hou-tien [33.18N, 112.28E], 2500 ft., *F. N. Meyer* 1855 (NA); Im Kreise Teng fong, 530 m. [34.27N, 113.02E], *Schindler* 131 (A, BM, E, G, K, W). HOPEH: Tientsin [39.08N, 117.12E], *Clemens s.n.* (E); Changli [39.44N, 119.13E], *Clemens* 6237 (E); Hsiaowutaishan [39.57N, 114.59E], *Fan Memorial Institute* 61773 (A); Men-Tau-Kou [39.56N, 116.02E], *T. F. King* 175 (NY, S); Paita, *Licent* 9652 (W); Tschili, Duang hu dien, *Limpricht* 2969



(K, s); western tombs, 200 m., *Liu* 478 (A, K); Jehol (Chengteh) [40.48N, 118.06E], *Nakai, Honda, & Kitagawa s.n.* (TI); Hsiang Shan, *Sheehan* 239 (NY). HUPEH: Huan-tou-san [31.15N, 114.15E], *Hugh s.n.* (BM). KANSU: Lanchou [36.03N, 103.41E], *Piassetski s.n.* (LE); eastern Kansu, anno 1885, *Potanin s.n.* (LE); Pai-shuiho, Kuangting, *Potanin s.n.* (LE); banks of Chulungapu-Nyipa, lower Tebbu country [34.23N, 103.01E], *Rock* 14994 (A); dry slopes of Nyibaku, lower Tebbu country, 7500 ft. [34.23N, 103.01E], *Rock* 14796 (A, E, K, P, UC, W); Peshwekian gorge, lower Tebbu country, 6800 ft. [32.48N, 105.07E], *Rock* 14553 (A, C, LE, S, US). KIANGSU: near Nanking, *Carles* 557 (E, K); Paohwashan, *Cheng* 4500 (P); Chuyong, *Ling* 2179 (UC); Ming tombs near Nanking, *F. N. Meyer* 1450 (A, NA); Hwang San Yü, *Ren & Tao* (UC); Mao Shan, Tan Yang [32.0N, 119.35E], *Tso* 1793, 1814 (A). LIAONING: Manchuria, Fu-shun (Shen-yang) [41.50N, 123.26E], *Yamatsuta* 1006 (TNS). PEKING MUNICIPALITY: envir. Peking, anno 1831, *Bunge s.n.* (K, LE, P); mts. west of Peking, *Bretschneider s.n.* (A, BM); rocky hillside north of summer palace, *Dorsett & Morse* 5585 (A, NY, P, US); Prince Park, Peking, *Liu* 7119 (K); on city wall, Peking, *F. N. Meyer* 1013 (A, MBG, NA, NY, P, TI). SHANSI: Mien Shan [36.49N, 112.02E], *Chaney* 1041 (NY, UC); Hwo shan (mts.) [36.40N, 112.05E], *Kabanov s.n.* (LE); east of Changchiagou, Wenshui [37.25N, 112.01E], *Kang* 150 (GH); Tchangkiatchoang, Tchely S.E., *Licent* 82 (P); Tsinn choei s'hien [36.45N, 112.41E], *Licent* 1464 (BM, P); Chin Yuan, near Hsu Chio-Chuan [36.29N, 112.20E], *Ling* 1621 (A, UC, US); Shueiyu [39.14N, 113.14E], *Sandberg* 163 (S); Hsia-hsien, Pei-shui-ko and Yüan-ch'ü Dist., Ssü-chiao-ho, 900 m. [35.05N, 111.24E], *H. Smith* 6103 (A, S). SHANTUNG: Meng Shan, Fei Hsien [35.16N, 117.57E], *Cheo & Yen* 246 (A, BM, G, P, W); Tsinanfu-Lung Tung, 300 m., *Chiao* 3086 (A, B, C, E, G, K, LE, NY, UC, US); Po-shan [36.29N, 117.50E], *Kao* 529 (A); Fangtse (Weihien), *Royal Forest Station* 328 (B). SHENSI: Tsinling-shan, Nauwutai pr. Hsingan [32.42N, 109.12E], 1500–1700 m., *Fenzel* 68 (W); Tsinling-shan centr. inter Mei et Liupa [33.40N, 106.55E], *Fenzel* 658 (W); Ningshenhsien, 1150 m., *Kung* 3073 (PE). SZECHUAN: Wei Kuan [31.29N, 103.16E], *Bock & Rosthorn* 2523 (A); near Hua Nin Pink, Han Yuen Hsien [29.21N, 102.43E], 2100 m., *Chiao* 1876 (A); Litang valley, Muli Dist. [28.20N, 100.48E], 10000–11000 ft. alt., *Forrest* 21330 (A, E, K, P, W, US); supra vicum Helugö in convalle fluminis Yalung ad septentriones oppidi Yen-yüen infra castellum Kwapi [27.30N, 101.40E], 2325 m., *Handel-Mazzetti* 2467 (A, W); River Valley of Fu pien [31.18N, 102.27E], *Potanin s.n.* (LE); near Tachienlu (Ta-tsien-lou) [30.03N, 102.02E], *Pratt* 138 (BM, DUB, E, G, GH, K, LE, P, US); mts. between Litang & Shou-Chu rivers, 3180 m., *Rock* 16904 (A, E, NY, US, W); Fu-pien Hsien [31.18N, 102.27E], 2750 m., *C. Wang* 21321 (A, TAI); Li-fan Hsien [31.32N, 103.19E], 3000 m., *C. Wang* 21608 (A); Mon-kong Ting, *E. H. Wilson* 278 (A, NA, photos); Fei-yueh-ling, near Tung River, *E. H. Wilson* 277 (A, NA, photos); northeast of Tachien-lu, dry valleys near Romichango, *E. H. Wilson* 2370 (A, US; 2370a lectotype of *K. apiculata*). YUNNAN: Yen Ching Shan [25.54N, 98.58E], *Forrest* 30068 (E); Muli, Kehsy [23.59N, 105.22E], *Yü* 14214 (A, E); Muli, near Lamasery, *Yü* 14860 (A, E). PROVINCE UNDESIGNATED: N. central China, Mt. Miao-uan-san, *Hugh s.n.* (BM); N. central China, Mt. Theu-kio-tsuen, *Hugh s.n.* (BM); N. central China, Mt. Lao-y-san, *Hugh s.n.* (BM); Kyoyokuwan-Sanho, *Togashi* 741 (TNS). Japan (naturalized). HONSHU. AOMORI PREF.: Hirosaki, *Knashi* 453 (KYO); FUKUI PREF.: Prov. Echizen, Ayukaya, Kunimimura, Nyu-gun, *Tashiro s.n.* (TNS); Wada Takahama-cho, Ooi-gun, *Kuwashima* 15037 (TNS); Iwayama-hill, Takahama-cho,



Prov. Wakasa, *Hori s.n.* (KYO); Takahama, Prov. Wakasa, *T. Nakai 1052* (KYO); Shiroyama in Takahama-cho, Prov. Wakasa, Ikenokochi, Togo-mura, Tsuruga-gun, *Tashiro s.n.* (KYO). HYOGO PREF.: Kasumi-cho, Kinohaki-gun, *J. Araki s.n.* (KYO); Kasumi-cho, Kinohaki-gun, *Hosomi s.n.* (KYO). ISHIKAWA PREF.: Ayukawa, Kunimi-mura, Niu-gun, *Tashiro s.n.* (KYO); Prov. Noto, Togi, *Kitamura s.n.* (KYO). IWATE PREF.: côtes de Kessenuma, *Faurie 6082* (G, P); Tsubaki-jima, Shizugawa-wan, Prov. Rikuzen, *Suzuki s.n.* (TNS). MIYAGI PREF.: Prov. Rikuzen, Motoyoshigun, Iwaisaki, *Sohma & Ohashi 127* (TI). NAGANO PREF.: Prov. Shinano, Mt. Hiuchi, *Sakurai s.n.* (A). Korea (naturalized). Anmyun-Do, Choong-Nam [36.30N, 126.22E], *Cho s.n.* (KFI); Ouen san [38.21N, 127.55E], *Faurie 64* (A, BM, KYO, LE, P, W); Deukjog Island [37.15N, 126.35E], *T. B. Lee s.n.* (SNU); Daebu Island [37.15N, 126.35E], *T. B. Lee s.n.* (SNU); Riverside, Suwon [37.16N, 127.01E], *Lee, Park, & Cho 3251* (SNU); Anmin Island, *Lee & Cho s.n.* (SNU); Sorai Beach, Whanghai Prov., *Mrs. R. K. Smith s.n.* (A, US); Koko, Prov. North Kesho [36.05N, 129.22E], *E. H. Wilson 8487* (A).

CULTIVATED. Africa: Tunisia. Jardin Mopitant, *Cuenod s.n.* (G). Asia: China. Summer palace grounds, Peking, *Armacost 95* (NY); Peking-Seityokuon Engeisikenzyo, *Togashi 2418* (TNS). Hong Kong. Hort. Bot. & Forestry Dept. 5923 (K). India. New Forest, Dehra Dun, *Raizada 2080* (E); Mangalor, Terr. Canara, *Hohenacker s.n.* (P). Israel. Jerusalem, *Linder s.n.* (S). Japan. Hirosaki, Aomori Pref., *Faurie 3452* (KYO, P); Tokyo, *Goto s.n.* (TAI); Prov. Chikuzen, Rukuoka Pref., Tokko Temple, Kyushu, *Kanisi s.n.* (TAI); Prov. Yamato, Matsuyama-cho, Uda-gun, *Koidzumi s.n.* (KYO); Morinoyakuen, Uda-gun, Nara Pref., *Koidzumi s.n.* (KYO); Asakawa, Prov. Musashi, Tokyo Pref., *Kunosato s.n.* (TAI); Yokohama, 28-VII-1862, *Maximowicz s.n.* (LE); temple Matsumoto-Toko-ji, *Nikai, s.n.* (TNS); Tanigawa, Prov. Kodzuki, Pref. Gumma, *Ouoma s.n.* (NA, S); ad ripam fluvii Matsia Gawa prope pagum Saija, *Pierot 569* (L, P); Hida, Honshu, *Shio 7215* (A); Omura, Prov. Hizen, Kyushu, *Tashiro s.n.* (KYO); Prov. Sagami, Todzuka, *Togashi s.n.* (TNS); Oohara, Kyoto, *Tuyama s.n.* (TNS); Yokohama Nursery Co. (E). Korea. Botanical garden, Ewaha Woman's University, *T. B. Lee s.n.* (SEU). Lebanon. Cam Liman, Hebeli, *Post s.n.* (G). Turkey. Boulevard facing Jardin Municipal, Constantinople, *Aznavour 527* (G); Göksu-Tal prope viam, *Wimmer 25* (W). U.S.S.R. Aschabad [37.30N, 57.30E], *Bornmüller 511* (K, P, W). Australia. Ross Street, O'Conner, Canberra, *Darbyshire 580* (K). Europe: Austria. Chemischen Institut in der Währingerstrasse, *Zerny s.n.* (W); Schönbrunn (W); Hort. Bot. Vind., 27 June 1806, *hb. Mertens* (LE); Landeskreuanstalt "am Steinhof," *Korb s.n.* (W). Belgium. Bot. Have, Bruxelles, *Lange s.n.* (C). Bulgaria. Deoushlea, *Petersen s.n.* (C). Cyprus. Dept. of Agriculture, Nicosia, *Lyenzamides 1308* (K). Czechoslovakia. Silesia, Opp. Opava in horto pagi Novy Dvur, *Elblova s.n.* (A); Moravia, Brünn, *Müller s.n.* (G, NY, S). England. Hort. Bot. Cambridge (A); Beaufort (Sussex), *Elwes* (DBN); between Gloucester Road and Earls Court, London, *Gerrans s.n.* (BM); Hampshire, *Horder s.n.* (E); Hort. Kew, *Aiton s.n.* (G); Chelsea Physic Garden, *F. G. Meyer 13962* (NA); Bromley, Kent, anno 1780, *Norman s.n.* (BM); Wakehurst Place, Ardingly, Sussex, *Wakehurst 629* (K); Cherkley Court, Surrey, *Jackson s.n.* (BM). France. So. France, *Ellis s.n.* (A); Arnas (Rhône), *Gandoger 333* (LE, MO); locality undesignated, anno 1786, *Lamarck s.n.* (P-LA; NA, photo); Hort. Cels, *L'Héritier s.n.* (G-DC); Arboretum segrezianum, Siene-et-Oise, Segrez, *Nicholson s.n.* (E, K); Hort. Vilmorin, Verrieres, *Vilmorin s.n.* (A); Hort. Montpellier, anno 1807 (LE); Hort. Paris, anno 1792, *Ventenat s.n.* (P-JU;



NA, photo); Jardin des Plantes, Paris, anno 1813, 1901, 1904, 1925 (P); Hort. Bot. Strasbourg, *Schneider s.n.* (A). **Germany.** Breslau, Königl. Bot. Gart., *Baenitz 1399* (A, DBN, E, GH, L, PH, S, WAG); Hort. Saltz-wedel, Frankfurt a/m, anno 1826, *Engelmann s.n.* (MO); Hort. Bot. Berol., anno 1906, *Hülphers s.n.* (S); Hort. Bot. Erlangensis, *Kaulfuss s.n.* (A); Hort. Bot. Stuttgart, *Mohr s.n.* (US); in gardens, Zweibrücken, *Mohr s.n.* (US); Darmstadt, *Purpus s.n.* (A); Schloss Heidelberg, *Springer s.n.* (WAG); George-born bij Schlangebeck, *Suringar s.n.* (WAG). **Greece.** Peloponnesus, Achaia, prope pagum "Kalavryta," *Bornmüller 349* (A, S). **Ireland.** Birr Castle, Co. Offaly, *Earl of Rosse s.n.* (NA); Donard House, Mrs. Heighington's Garden (DBN). **Italy.** Villa Taranto, Pallanza, *McEacharn s.n.* (BM); Hort. Bot. Florence, anno 1814 (S). **Netherlands.** Hort. Bot. Amsterdam, *Springer s.n.* (WAG); Bot. Gard. Cantonspark, *Mennega s.n.* (E); town garden, Haarlem, *Springer s.n.* (WAG); Helsdorf, park Graf von Spee, *Suringar s.n.* (WAG); Rengerspark, Leeuwarden, *Hoogland 434* (L); Leiden, Gemeentekwekerij, *Hattum s.n.* (L); arboretum 'De Dreijen,' Wageningen, *Bruijn 2142, 2143, 2159, 2160, 2166* (NA). **Portugal.** Jardim do Ultramar, Lisboa, *Reis s.n.* (K). **Spain.** Gerone, Figueras, *Augustin 5113* (G, W); Hort. Bot. Valencia, anno 1852, *Bourgeau s.n.* (P). **Turkey.** Birge garden Rumel Hissar, *Post s.n.* (G). **U.S.S.R.** Tbilisi, anno 1894, *O. A. & B. A. Fedtschenko s.n.* (LE); Hort. Bot. Petrop., anno 1771, *Laxmann s.n.* (LINN, lectotype; photo at NA); Hort. Bot. Nikita, Yalta, anno 1837, *Trautvetter s.n.* (LE). **North America:** U.S.A. ARKANSAS: Hot Springs, *Everett s.n.* (MO). CALIFORNIA: Willits, Mendocino Co., *Bacigalupi 9115* (UC); Lakeport, *Bonar s.n.* (A, UC); lower Orpet Park, Santa Barbara, *Broder 1246* (NA); Jackson, Amador Co., *Clemens s.n.* (CAS); Elysian Park, Los Angeles, *Hall 7992* (UC); Univ. California campus, Davis, *Hansen s.n.* (UC); Los Angeles State & Co. Arboretum, *Jativa 2269* (NA); Univ. California Bot. Gard., Berkeley, *Kruckeberg s.n.* (NY); capitol grounds, Sacramento, *McClintock & Leiser s.n.* (CAS); garden Merritt Island, 3.5 mi. so. Clarksburg, Yolo Co., *Quick 6818* (CAS); U. S. Exp. Stat., Chico, *Rixford s.n.* (CAS); Santa Clara, *Robinson s.n.* (UC); Dorothy Twisselmann Ranch, e. San Luis Obispo Co., *Twisselmann 13704* (CAS); San Bernardino, *H. A. Walker 3900* (US); Golden Gate Park, *Walther s.n.* (CAS); C. Menzies' place, Mill Valley, *Walther 81* (A, CAS); Huntington Bot. Gard., *Walther 104* (A); Bel-air, Beverly Hills, *Walther 43* (CAS). CONNECTICUT: New Haven, *Eaton s.n.* (GH). DELAWARE: Wm. P. Bancroft's garden near Wilmington, anno 1878, *Canby s.n.* (NY); Mt. Cuba Bot. Park, Greenville, *Kelsey 145* (A, K, NA); Rehoboth Ave., Rehoboth Beach, *McVaugh 6592* (GH, NA, NY). DISTRICT OF COLUMBIA: Capitol Grounds, *Lyon s.n.* (CAS); grounds, Department of Agriculture, *Sudworth s.n.* (US); Monument Grounds, *Van Eseltine s.n.* (NA); St. Elizabeth Hospital Grounds, *E. H. Walker 751* (NA); U. S. National Arboretum, *P. I. 21973* (NA), *P. I. 130117* (CAS, NA, UC). GEORGIA: so. side Coop. Ext. Bldg., Univ. Georgia, Athens, Clarke Co., *Meyer & Mazzeo 14415* (NA). INDIANA: roadside 3 mi. so. New Harmony, Posey Co., *Hermann 6132½* (NA); Sigma Nu lawn, Greencastle, Putnam Co., *Welch 6906* (GH, MO). KANSAS: Emporia, *Agrelius s.n.* (MO). KENTUCKY: Calvert City, Marshall Co., *Eggleston 4842* (NY). LOUISIANA: Hodges Gardens, Many, Sabine Parish, *Meyer & Mazzeo 11797* (NA). MARYLAND: Corner East-West Highway and Jones Mill Rd., Bethesda, Montgomery Co., *F. G. Meyer 12570* (NA). MASSACHUSETTS: Arnold Arboretum, Jamaica Plain, *21980-A* (A, C, CAS, K, MO, NA); Manning Garden, North Salem, *Morse s.n.* (A); Hort. Brookline, *Sargent s.n.* (A); President Clark's place, Amherst, *Stevens s.n.* (US); Rockport, *Wagenknecht & Howard s.n.* (A). MISSISSIPPI:



"Mistletoe," garden of S. H. Lambdin, Natchez, Adams Co., *Meyer & Mazzeo* 11688 (NA). MISSOURI: Kansas City, *Bushnell s.n.* (GH); Tower Grove Park, St. Louis, *Croat* 8830, 8877 (MO); Univ. Missouri campus, *Drushel* 1983 (P); Missouri Botanical Garden, *Kellogg s.n.* (CAS); Webster Groves, *Lodewyks s.n.* (MO). NEVADA: grounds of Lahonton Motel, Fernley, Lyon Co., *Follett s.n.* (CAS). NORTH CAROLINA: Biltmore, Buncombe Co., *Biltmore* 9624 (G, P, S, UC, W); Winston-Salem, *Schallert s.n.* (W). NEW JERSEY: institute grounds, Freehold, *Wood s.n.* (NY); Duke's Park, Somerville, *Fisher s.n.* (PH); New Egypt, *Grove* 804 (PH). NEW MEXICO: college farm, Mesilla Park, *Standley s.n.* (US). NEW YORK: Ithaca, *Bailey* 602 (NA); University Heights, New York Univ. campus, *Drushel* 1923, 2838 (P); Riverside Park, New York City, *Archer s.n.* (GH); New York Bot. Gard., *P. Wilson s.n.* (NY). OHIO: Ohio State Univ. campus, *Cooke s.n.* (A). OKLAHOMA: locality undesignated, *Featherly s.n.* (MO). PENNSYLVANIA: Longwood Gardens arboretum, *Bates* 71 (A, NA); Happel Garden, Monocacy, Berks Co., *Brumbach* 6330 (A, NA); trial plots at Fordhook Farm, Doylestown, *Dudley s.n.* (A); Barnes Arboretum, Merion, *Fogg s.n.* (CAS); Bartram's garden, Philadelphia, *Short s.n.* (MO). TENNESSEE: Agr. campus, Univ. Tennessee, *Meyer & Mazzeo* 12842 (NA); garden of Sam Caldwell, Nashville, Davidson Co., *Meyer & Mazzeo* 13161 (NA); Tennessee Valley Nursery, Winchester, Franklin Co., *Meyer & Mazzeo* 13082 (NA). UTAH: Brigham Young Univ. campus, Provo, Utah Co., *Daines s.n.* (A); Salt Lake City, *Lindsay s.n.* (A). VIRGINIA: Maymont Park, Richmond, *Meyer & Mazzeo* 14517 (NA). WASHINGTON: Seattle, *Schallert* 489 (MO). Oceania: New Zealand. Linwood Nursery, Christchurch, *Sykes s.n.* (NA).

Both the genus and the type species, *Koelreuteria paniculata*, were based on a cultivated plant without a type specimen being designated. In the absence of a type, the plate, published with the protologue, would serve adequately as the nomenclatural type, except for the fact that a specimen does exist in the Linnean Herbarium in London. In 1771 Laxmann sent a complete leaf to Linnaeus, most likely from the type tree, along with a description of the tree, which he described in 1772 as *Koelreuteria*. The sheet in the Linnean Herbarium, furthermore, bears an annotation by Linnaeus: "Chinensis arbuscula ex Horto Petropolitano Laxman." Since the identification of the material is not in question, the specimen in the Linnean Herbarium (514.5) serves as the nomenclatural type (lectotype) of *K. paniculata* Laxmann, which in turn is the type species of the genus.

The name *Koelreuteria paullinioides* of L'Héritier, dating from 1789, is clearly a substitute name for *K. paniculata*, of 1772. However, the accompanying figure, published in 1792, is something of a puzzle. The citation of both the name and plate number in the protologue, e.g. *K. paullinioides*, tab. 19 (L'Héritier, 1788), seems clear enough, yet the name *K. paniculata* appears on the plate and not *K. paullinioides*. Whether this mistake was intentional or an oversight will probably never be known. The drawing in question was executed by Redouté during his visit to Kew Gardens in 1786 and was probably completed, with the name *K. paniculata* fixed to the plate, before L'Héritier had proposed the substitute name. The wrong name on the plate, more than likely, was an oversight not caught by L'Héritier before the plate went to press. Of interest in the



whole matter is a letter from L'Héritier to Dryander, dated September 1, 1788, which provides some revealing evidence for the change in name from *K. paniculata* to *K. paullinioides* (Stafleu, 1963). In his letter L'Héritier wrote that "with regard to those [names] published only in dissertations or academic memoirs, I think that one can change them without difficulty, not for the pleasure of changing, but only if one has the opportunity of giving a better one. Take for instance *Koelreuteria* . . . the trivial name seems to me to be the one which compares the genus with the nearest allied genus," in this case *Paullinia*.

Rehder and Wilson described *Koelreuteria apiculata* (1914) as being "readily distinguished by its often simply pinnate leaves, much broader less coarsely incised leaflets with less acute teeth, by its ovate or oblong-ovate, acute sepals, its smaller petals and chiefly by its sharply pointed fruit with acute or acuminate valves." However, there is nothing constant in these characters to distinguish Rehder and Wilson's plant from *K. paniculata* itself.

By some authors, *Koelreuteria paniculata* was thought to be indigenous to Korea and Japan, but no evidence exists to support this view. However, the tree has become naturalized in both areas as a result of earlier introductions from China. The plant was not listed by Nakai (1909–1911; 1915–1936) or by Trollope (1918–1920) among the indigenous trees of Korea. Both Wildemann (1903) and Matsumura (1912) believed the plant was not indigenous to Japan, and Ohwi (1965) indicated that it is "often naturalized near seashores and sometimes planted around temples." Blume (1849) was even more definite (from the Latin): "Habitat: In China, whence, on the authority of the *Encyclopaedia Japonica*, it was first brought to Japan from a monastery in the Thien tai province of Tschekiang by a wandering monk, in the year 1220, and planted in the garden of a monastery in the city of Mijako [Kyoto]." Dr. Hiroo Kanai of the National Science Museum in Tokyo (pers. comm.) strongly supports the view that *K. paniculata* was introduced to Japan from China and was planted around Buddhist monasteries, perhaps in the years following the introduction of Buddhism into Japan in A.D. 552. Now *K. paniculata* is widely naturalized in various parts of Japan, particularly on the Japan seaside of Honshu.

*Koelreuteria paniculata* is easily distinguished from the other two species of the genus by its predominantly pinnate leaves (although bipinnate leaves may sometimes occur), by its coarsely crenate-serrate to pinnatisect and lobulate leaflets only slightly unequal at the base, and by its capsules, which are conoidal in shape.

VERNACULAR NAMES. China: *Wu-La* (Hopeh); *Luan Shu*, Luan tree; *Mu Luan*, woody Luan; *Hei Se Yeh Shu*, black leaf tree; *Wu Yeh Kao*, black leaf plaster (Hopeh); *Cha Yeh Chu* (Peking). In the United States the names goldenrain-tree, pride-of-India, China-tree, and varnish-tree have been used, although the name goldenrain-tree is the most common.



USES. Chow (1934) wrote that *Koelreuteria paniculata* is "widely cultivated around temples, palaces, gardens, and residences in Peiping. This tree is a very widespread and widely cultivated species in China, as the tombs of officials were usually surrounded by trees of this species in former times. Preferring to grow in dry, sandy plains and valleys. The wood is hard and heavy, close-grained, fine in texture, may be used for making furniture, interior finish, and for fuel, etc. A black dye may be obtained from its leaves and a yellow dye also from its yellow flowers."

Blume (1849) indicated that in China the seeds are used in religious rites in place of rose petals, for which reason this tree is considered most sacred.

According to Chen (1957), *K. paniculata* is also used for medicine, and "the leaves can be used for a blue dye. Among the seeds sold to dyers' shops are the pea-shaped black seeds which can be used as a rosary. According to the *Book of Rites*, what should be planted on the graveyard of an emperor is *sung* (pine tree), that of a feudal prince is *po* (the cedar), of a high minister is *luan* (*Koelreuteria paniculata*), of an official is *huai* (*Sophora japonica*), and a commoner is the *liu* (willow)." Other uses in China include the use of oil from the seeds as a lubricant and as a soap.

In Japan, *Koelreuteria paniculata* has only one recorded use, the seeds as religious beads, and only one currently used vernacular name, *Mokugenji* or *Mokugenzju* (fide Miquel, 1867). The name *Sendan-bano-bodai-ju*, recorded by Blume (1849), appears to be no longer in use.

GARDENS. According to Laxmann (1772), *Koelreuteria paniculata* had been grown in St. Petersburg for about 20 years prior to 1771, fixing the date of introduction at about 1750.

In England, W. Aiton (1789) recorded that *Koelreuteria paniculata* was first grown by George William Coventry, the 6th Earl, in 1763, although the record is without further documentation. One surmises that the seeds may have been obtained from Jussieu in Paris, either directly or possibly through sources at the Royal Gardens at Kew, since *K. paniculata* was, in fact, in cultivation at Kew in 1788 (LINN, coll. J. E. Smith). An even earlier specimen dates from 1780, collected by a Mr. Norman of Bromley, Kent (BM).

In France, *Koelreuteria paniculata* was cultivated probably as early as in England, since Bernard de Jussieu received seeds from D'Incarville around 1750 (D'Incarville died in 1757). The earliest documented specimen from France dates from 1786, collected by J. B. Lamarck (P-LA).

In Germany, *Koelreuteria paniculata* was grown as early as 1796 according to Willdenow (1796).

In the United States, the earliest known introduction dates from 1809 by Thomas Jefferson, who received seeds from Madame de Tessé (for details see Betts, 1944, pp. 387 & 454).

Whether Jefferson's seedling grew to maturity is unknown; however, we know that *Koelreuteria paniculata* almost certainly became established in Philadelphia after 1809, since a Col. Robert Carr of Philadelphia sent



plants to Thomas Say of New Harmony, Indiana, via New Orleans in 1832 (Mrs. Bruce English, pers. comm.)

#### CULTIVARS OF KOELREUTERIA PANICULATA

- 1a. *Koelreuteria paniculata* Laxm. cv. *Fastigiata* Krüssmann, Hand. Laubgehölze. 43. 1960; Hillier's Man. Trees & Shrubs. 1972; Bean, Trees & Shrubs (ed. 8) 2: 508. 1973. CLONOTYPE: not seen.

*Koelreuteria paniculata* var. *fastigiata* Bean in Kew Bull. Misc. Inf. 4: 101. 1929; Rehder, Man. (ed. 2) 592. 1940. A clonotype specimen was not cited.

*Koelreuteria paniculata* f. *fastigiata* (Bean) Rehder, Bibl. 434. 1949.

A tree with a narrow fastigiate habit, the branches all more or less parallel to the main trunk. Flowering not recorded.

SPECIMENS EXAMINED. Trompenburg Arboretum, Rotterdam, Netherlands, *F. G. Meyer* 6516 (NA); U. S. National Arboretum, Washington, D. C., *F. G. Meyer* s.n. (NA).

This cultivar originated as a chance seedling at the Royal Botanic Gardens, Kew, from seeds sent to a Miss Corner, of The Grove, Hammer-smith, England, in April, 1888 (Bean, 1929). Bean (1973) indicates that the mother tree still survives near the Ruined Arch at Kew. The plant is rare in botanical gardens and is only occasionally offered by nurseries.

- 1b. *Koelreuteria paniculata* Laxm. cv. *September* McDaniel & March in Am. Hort. Mag. 46(2): 95, 96. 1967. CLONOTYPE: campus of Indiana University, Bloomington, Indiana, August 27, 1970, *Meyer & Terrell* 12459 (NA).

A selection of the species which flowers at the end of August and in early September in Indiana and Washington, D. C. Normally, flowering of *Koelreuteria paniculata* occurs from mid-June to early July, although a tendency for later flowering is a known manifestation of seedling variants in cultivation.

Dr. J. C. McDaniel, of the Horticulture Department at the University of Illinois at Urbana, discovered a group of three goldenrain-trees on the university campus at Bloomington, two of which were in full flower on August 25, 1958. Later one of the trees received the name cv. *September*, after it had been determined that the late flowering trait was normal and consistent for the parent plant. Seedlings raised from the mother plant also tend to maintain the late flowering habit.

An unnamed variant of *Koelreuteria paniculata* with white variegated leaves was collected in England in 1885 (κ).

2. *Koelreuteria bipinnata* Franchet in Bull. Soc. Bot. France 33: 463, pls. 29, 30. 1886; Sarg. in Gard. & Forest 1: 376, 377. 1888;





FIGURE 10. *Koelreuteria bipinnata*: habit, leaves (*Delavay s.n.*, 13 Sept. 1887); capsules (*Spalding s.n.*, 29 Oct. 1971, cultivated),  $\times \frac{1}{4}$ .

Franchet in *Pl. Delavayanae* 2: 143. *pls.* 29, 30. 1889; Smith in Forbes & Hemsley, *Jour. Linn. Soc. Bot.* 36: 487. 1904; Elwes & Henry, *Trees Gr. Brit. & Ireland* 7: 1931. 1913; Radlk. in Engler, *Pflanzenr.* IV. 165: 1332. 1933. LECTOTYPE: *Delavay 1870a* (P),



flowers. Collected July 26, 1885. It is necessary to select a lectotype specimen to separate flowering and fruiting specimens, collected on different dates and originally assigned the same number, *Delavay* 1870. FIGURES 1, 4, 5, 10–12.

*Koelreuteria integrifoliola* Merr. in Philipp. Jour. Sci. 21: 500. 1922; Radlk. in Engler, Pflanzenr. IV. 165: 1334. 1933. HOLOTYPE: (McClure) Canton Christian College 7060 (A); isotypes (NY, UC, US).

*Koelreuteria bipinnata* var. *puberula* Chun in Acta Phytotax. Sinica 3: 408. 1955. HOLOTYPE: Ching 7668 (Herb. Biol. Lab. Sci. Soc. China, Nanking, not seen); isotypes (A (two sheets), NY, UC, US).

Tree to ca. 20 m. in height and to ca. 60 cm. in diameter; lenticels round to lens-shaped, pustulate, corky, cinnamon-brown; twigs glabrous to uniformly puberulent. Leaves spreading, bipinnate, 27–30 cm. long, 23–40 cm. wide; rachis with a line of short hairs on the upper side or glabrous; leaflets (3–)8–10(–12) on the major leaf divisions, weakly oblique, dull dark green with rather prominent impressed veins above, cuneate to rounded at base, narrowly ovate to narrowly elliptic, 7.8–14.1 cm. long, 2.1–5.1 cm. wide, entire or uniformly serrate except at base, acute to short-acuminate, the terminal leaflet sometimes narrowly obovate, as large as or larger than the others, short-puberulent on the midvein above, the hairs beneath longer and in tufts, sometimes mixed with crispate hairs and glands, rarely glabrous, sessile or with petiolules to 3 mm. long. Inflorescence 35–70 cm. long, 20–40 cm. wide, densely puberulent, sometimes glandular; pedicels 2–3 mm. long with scattered hairs; calyx lobes ovate, obtuse, to more or less deltoid and acute, fimbriate-glandular, otherwise glabrous or with scattered hairs on the outer face; petals 4 (the 5th petal often rudimentary), limb 5.5–9.5 mm. long, 1.5–3 mm. wide, obtuse or sometimes acute, appendages often deeply lobulate-undulate, claw 2–3 mm. long, up to twice as long as the calyx lobes, densely villous mainly on margins and at base; stamens long-exserted, with scattered long straight hairs, especially in the lower half, anthers gray to blackish. Capsules ellipsoidal, the valves elliptic to rotund (placenta continuous and nonwinged), 3.7–6.6 cm. long, 3–5 cm. wide, inner side somewhat lustrous, reticulate-veined on outer side, rose-purple while young, with scattered hairs on middle of valves, brownish at maturity; styles 3–4.5(–6) mm. long; seeds nearly spherical, 5.5–6 mm.  $\times$  5.5–7.5 mm., dark brown.

DISTRIBUTION. China: Anhwei, Chekiang, Hunan, Hupeh, Kiangsi, Kiangsu, Kwangsi, Kwangtung, Kweichow, Szechuan, and Yunnan; also cultivated in gardens.

Flowering ranges from July 10 to August 28 (September 30 recorded on one specimen), with fruiting from the middle of August to October. Cultivated plants usually flower in late August and September and fruit in October and November. Various habitats have been recorded: open fields, hillside forests, light woods, thickets, and roadsides, from altitudes of 250 m. to 2600 m.



REPRESENTATIVE SPECIMENS. China. ANHWEI: Wu Yuen [29.17N, 117.54E], *Ling* 7871 (UC). CHEKIANG: Ningpo Hills, *Barchet s.n.* (US); Hangchow [30.15N, 120.10E], *Ching* 2604 (A), 3768 (UC); Tien moo shan [30.15N, 120.07E], *Ching* 5199 (A); Ningpo, *Faber* 54 (A, K, LE, NY, P); West Lake, *Y. L. Keng* 1200 (A, UC); near Linhota, Hangchow, *Migo s.n.* (A). HONAN: Chi-Kung Mt. [31.51N, 114.07E], *Li, Chang, & Ni* 161 (PE). HUNAN: Ch'ien-Yang Hsien, Hsueh-Feng Mt. [27.36N, 110.50E], An-Chiang Agricultural

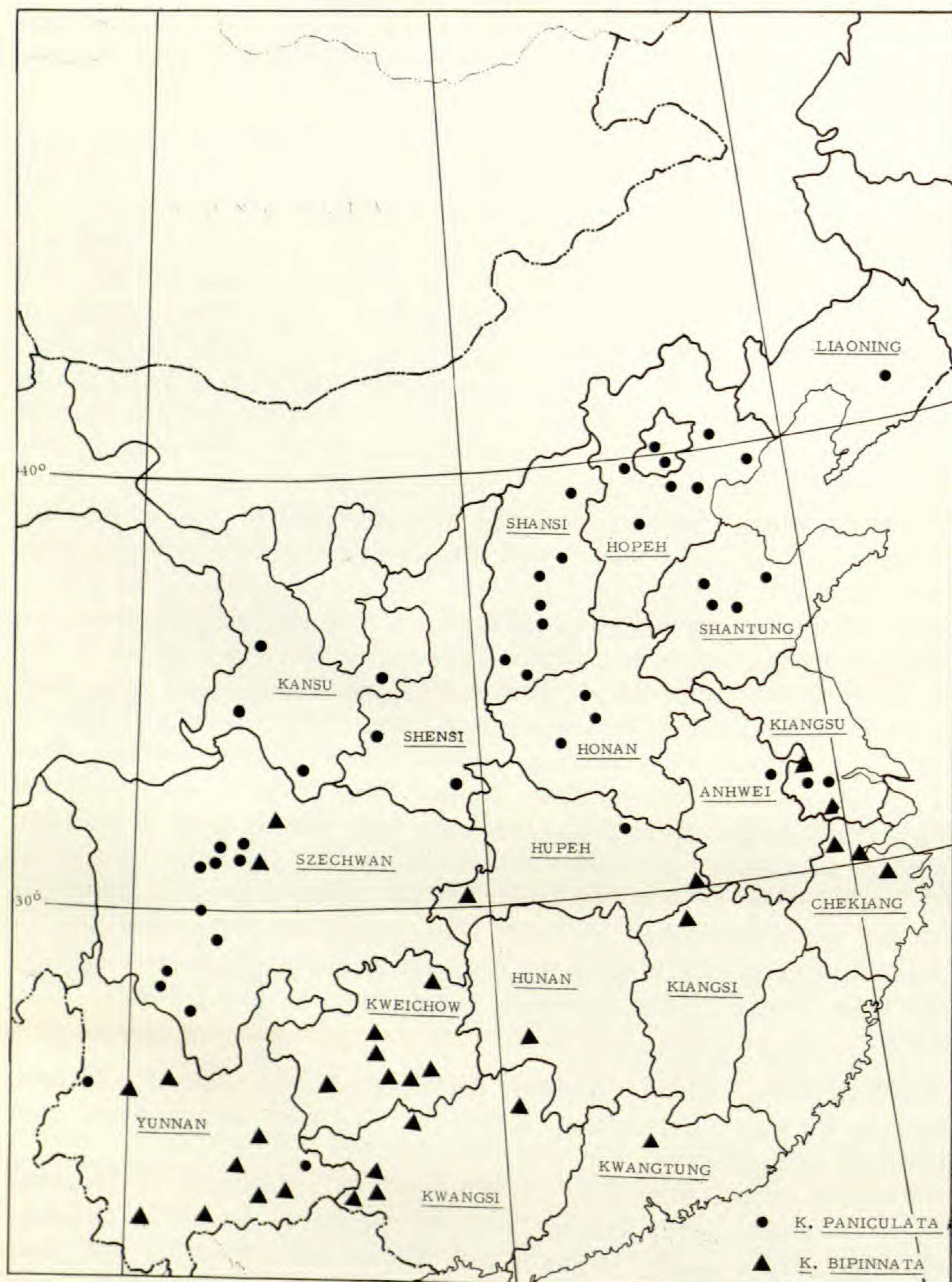


FIGURE 11. Distribution map of *Koelreuteria paniculata* (circles) and *K. bipinnata* (triangles).



School, 9 Sept. 1953 (PE); inter vicos Gauschasse et Lududsai distr. Wukan et Pautjing, *Handel-Mazzetti* 12552 (A, w); Heng-Shan Hsien, Nan-Yo [27.15N, 112.44E], 0783 *Hunan Team* (PE). HUPEH: Chienshih Hsien [30.37N, 109.38E], *Chow* 1538 (A, E, NY); Nang Yang Ho [30.32N, 116.04E], *Chun* 3865, 3868 (A), 4210 (E); W. Hupeh, *E. H. Wilson* 1609 (A, DBN, E, LE, NY, P, US, W). KIANGSI: Che-yi-shuan, Kwang-kan shan Mt., *Hsiung* 06409 (A). KIANGSU: Purple Mt., *Chiao* 342 (UC); Kai-wei monastery, V. I-Shing, *H. Keng* 2615 (A); Shan-Chien monastery, V. I-Shing [31.22N, 119.50E], *H. Keng* 2536 (A). KWANGSI: Bako Shan, w. Po-Seh Hsien [23.54N, 106.37E], *Ching* 7668 (A, NY, UC, US); Ching-Hsien, An-Teh village, *Ko* 55806 (A); Ching Sai, rd. to Piao-Lin village [23.08N, 106.25E], *Ko* 55523 (A); Ling Wun Dist., *Lau* 28685 (A); Ta-chiang-yuan village & vicinity, Chin-kang-shan, Kwei-lin Dist. [25.17N, 110.17E], *Tsang* 28321 (A, NA, UC, US); Nan-Tan Hsien, Wang Chang [24.58N, 107.33E], *Wang* 40962 (A). KWANGTUNG: Lo-Fou Mt., Hua-Shou T'ai [23.54N, 113.54E], (*N. C. Chen*) *Academia Sinica* 41678 (PE); Ying Tak Dist., Fringer Pt. Temple [24.10N, 113.24E], *Levine* 3484 (A, NA); Shuikwaan, on river banks near the monastery at low altitudes, (*McClure*) *Canton Christian College* 7060 (A, NY, UC, US); Yam No Mt., Mui Uen Dist., *Shang* 74 (A, NA). KWEICHOW: Pin-fa [26.04N, 107.03E], *Cavalerie* 197, 3190 (BISH, E, G, NA, P); Man cu Cho, *Schock* 405 (A, s, US); Szenan [27.56N, 108.14E], *Steward, Chiao, & Cheo* 345 (A, BM, LE, NY, P, s, w); Swan-liu, *Teng* 90749 (A); Sanhoa, Yao-ren-shan [25.59N, 107.52E], 400 m., *Tsiang* 6237 (A, NY), 6367 (PE, NY); Tuhshan [25.50N, 107.32E], 400 m., *Tsiang* 6606 (NY, PE), 6747 (NY); Pingchow [25.50N, 107.19E], *Tsiang* 7097 (NY); Kweiyang [26.35N, 106.43E], *Tsiang* 8490 (NY); Siuwen [26.51N, 106.35E], *Tsiang* 8701 (NY). SZECHUAN: Kuanhsien [31.00N, 103.37E], *Chien* 5368 (E, UC); Pehchuan Hsien (Sihchuan), *Fang* 5566 (A, E, NA, P). YUNNAN: in silva Ta-long-tan, supra Tapin-tze, *Delavay* 1870a (P, lectotype); Ta-long-tan, 21 July 1886, *Delavay s.n.* (BM, C, E, G, P), *Ibid.*, 13 Sept. 1887, *Delavay s.n.* (BM, E, G, LE, NY, P); Lao-kouy-chan, près My-le [24.37N, 103.34E], *Ducloux* 3995 (P); Wen-shan-hsien, Shii-guu [23.44N, 104.14E], *Feng* 11387 (A); Si-chour-hsien, Hsin-Cheih [23.27N, 104.40E], *Feng* 12611 (A); mts. to no. of Mengtsze [23.20N, 103.21E], 7000 ft., *Henry* 9099 (A); Hsi-ling-ten village, 5500 ft., Mengtsze, *Henry* 9103 (A, E, KE, MO, NY, s, US); Pat-ching [22.50N, 100.24E], *McLaren* 215 (C, E); forêts de San-kia, 2600 m., *Maire s.n.* (P); Hay-y près Lou lan [22.54N, 102.03E], *Ngueou* 673 (E); env. de Ou-se-tchong, *Sen* 3025 (BM, P); Mao Nieou chan, via Pien kio ad ta pen tse [26.16N, 101.04E], *Ten* 288 (A, E).

CULTIVATED. Africa: Egypt. Barrage Medicinal Garden, *Ibrahim & Mahdi* 152 (CAI, NA); Agricultural Museum Garden, Dokki, Giza, *Mahdi s.n.* (CAI, NA); Plant Island, Assuan, *Mahdi* 58 (CAI, NA); Zoological Garden, Giza, *Mahdi s.n.* (CAI, NA); Orman Garden, Giza, *Mahdi s.n.* (CAI, NA); Faculty of Agriculture, Giza, *Hadidy s.n.* (CAI, NA); Alfred Bircher's garden, El Saff, *Täckholm & Elsayed s.n.* (CAI, NA). Asia: China. SZECHUAN: Kiating, *Tai* 295 (A). Japan. Government Forest Exp. Station, Asakawa, Pref. Tokyo, *Hayashi s.n.* (TNS); Kyoto, Takeda Herbal Garden, *Takahashi* 286 (NA). Europe: England. Temperate house, Royal Botanic Gardens, Kew, *Elwes & Henry s.n.* (DBN); Arboretum, Royal Botanic Gardens, Kew, anno 1912, *Bean s.n.* (K). Ireland. Birr Castle, Co. Offaly, *Earl of Rosse s.n.* (NA). North America: U.S.A. CALIFORNIA: 1616 Gillespie Street, Santa Barbara, *Broder s.n.* (NA); Los Angeles State & County Arboretum, *Jativa* 2264, 2266, 2268, 2270 (NA); residential planting, Montecito, Santa Barbara Co., *McClintock s.n.* (CAS); Univ.



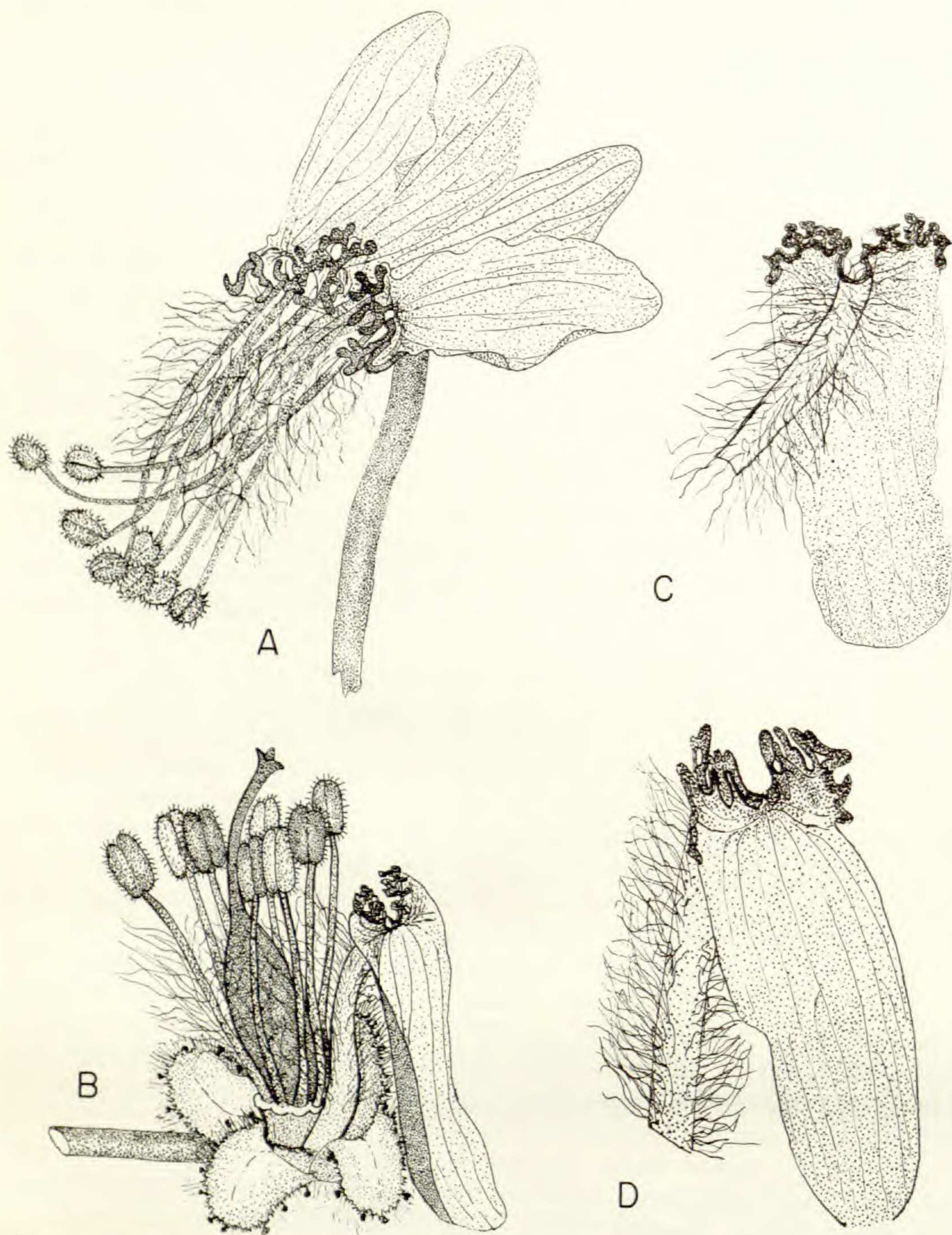


FIGURE 12. *Koelreuteria bipinnata*: A, staminate flower,  $\times 7\frac{1}{2}$ ; B, pistillate flower showing fimbriate-glandular calyx lobes, position of corolla lobe, sterile stamens, and young capsule,  $\times 7\frac{1}{2}$ ; C, corolla lobe (ventral side), showing villous claw and limb with basal appendages,  $\times 15$ ; D, corolla lobe (dorsal side),  $\times 15$ .

California Bot. Gard., Los Angeles, *McClintock s.n.* (CAS); street tree, 1523 Castillo St., Santa Barbara, *Moran 2612* (SBBG); residential planting, 403 No. San Gabriel Blvd., Los Angeles Co., *Spalding s.n.* (CAS, NA); Hillside Park, Santa Barbara, *Van Rensselaer 1296* (SBBG); Franceschi Park, Santa Barbara, *Van Rensselaer 1314* (SBBG, UC). FLORIDA: Fairchild Tropical Garden, *Gillis*



8550 (A, NA). PENNSYLVANIA: Arboretum of the Barnes Foundation, *Fogg s.n.* (NA); F. D. Moore & Sons, nursery, Narberth, *Meyer & Mazzeo 12572* (NA).

*Koelreuteria bipinnata*, as the basionym and valid name for the species, has been confused by botanists and horticulturists with *K. integrifoliola*, a name first applied by E. D. Merrill for the "second representative of the genus to be found in Kwangtung Province, rather strongly characterized by its entire leaflets." However, as the present study has shown, plants with entire leaflets are not entirely restricted to Kwangtung, but, in fact, occur on a random basis and in varying degrees throughout the known distribution of *K. bipinnata*. Sometimes both entire and serrate leaflets may occur on the same branch, as in *E. H. Wilson 1609* and *Tsang 28321*, although more often herbarium specimens show material with either entire or serrate leaflets, reflecting more the collector's choice of material than the variation in a given plant. Furthermore, observations by Dr. John M. Fogg, Jr. (pers. comm.) have shown that a plant labeled *K. integrifoliola* at the Arboretum of the Barnes Foundation at first appeared with entire leaflets but later, during the course of development, produced leaves with serrate leaflets. This change seems to suggest an expression of latent juvenility, since we know that seedlings of this plant produce leaflets with strongly serrate margins. In any case, the name *K. integrifoliola* is without a firm taxonomic base.

*Koelreuteria bipinnata* has also been confused with *K. elegans* from Taiwan, although the two are clearly separable on discrete morphological grounds (see TABLE 1).

TABLE 1. Characters distinguishing *K. bipinnata* from *K. elegans*.

CHARACTER	<i>K. bipinnata</i>	<i>K. elegans</i>
LEAFLETS	weakly oblique, acute to short-acuminate; dull green above, veins obvious, especially in living plants	usually strongly oblique, sometimes caudate; smooth and lustrous above, veins barely obvious in living plants
CALYX LOBES	fimbriate-glandular	ciliate-glandular
PETALS	4, rarely 5	5 or 4
CAPSULES	valves 3.7–6.6 cm. long, 3–5 cm. wide	valves 3.4–5(–6) cm. long, (2.5–)3.1–4.6 cm. wide
DISTRIBUTION	southern China	Taiwan and Fiji

VERNACULAR NAMES. *Feng-chui-kuo* (Yunnan, fide *Feng 12611*); *Fu Yu Yeh Luan Shu*, bipinnate leaf Luan tree; *Hua Ch'iu Shu* (Hunan); *P'ao Hua Shu Hsing-shan*, bubble-flower tree (Hupeh); *Un Tsing-pa'ko* (Kwangtung, fide *Tsoong 1066*); *Shan Ts'o* (Cantonese).



GARDENS. According to Riedel (1957), *Koelreuteria bipinnata* was introduced into the United States in 1911 by Dr. Francesco Franceschi of Santa Barbara, California. The species is now also grown in Florida, and recently it was introduced to the mid-Atlantic region of the eastern United States, where it appears to be completely hardy in Philadelphia and Washington, D. C. It is also cultivated in China, Japan, and Egypt. Seeds of *K. bipinnata* were sent to France by Delavay in 1887 from Yunnan; however, the plant never became established in Europe, although it was offered at least once in the trade by Simon-Louis, Cat. 44 (1908). Until recently, the Earl of Rosse, who lives in Ireland, had the only living plant of *K. bipinnata* known to exist in Europe.<sup>5</sup>

3. *Koelreuteria elegans* (Seem.) A. C. Sm. in Contr. U. S. Natl. Herb. 30: 518. 1952; Parham, Pl. Fiji Islands 174. 1964.

Tree 7–25 m. in height, to ca. 50 cm. (2 m. recorded in Taiwan) in diameter; lenticels round to lens-shaped, pustulate, corky, cinnamon-brown; bark peeling in square plates, rough, somewhat corky, furrowed lengthwise. Leaves bipinnate, the odd terminal leaflet absent or much reduced, 25–60 cm. long, 15–44 cm. wide; rachis glabrous or short-hairy on the more or less grooved upper side; leaflets 8–17 on the major leaf divisions, strongly oblique, smooth and lustrous with barely manifest veins above, lanceolate to narrowly ovate to elliptic, 5.5–9.2(–10.2) cm. long, 1.3–3(–4.2) cm. wide, entire to irregularly crenate-serrate, long-acuminate to caudate at the tip, glabrous or with scattered straight hairs on the veins above and on petiolule, midvein beneath sparsely hairy with tufts of hairs in the axils and often with glands interspersed on the midvein and veinlets, sessile or with petiolules to ca. 3 mm. long. Inflorescence 30–50 cm. long, 20–25 cm. wide, densely puberulent and glandular, especially at anthesis, less so in fruit; flowers mildly sweet-fragrant; calyx lobes ciliate-glandular; pedicels scattered-puberulent or glabrous; petals usually 5 or 4, rarely 6, limb 5.5–7 mm. long, 1.5–3.5 mm. wide, acute or obtuse to rounded, appendages lobulate-undulate, claw 2–5 mm. long, densely villous; stamens densely villous near base, 4.5–10.1 mm. long. Capsules ellipsoidal, the valves rotund to suborbicular (placenta continuous and nonwinged), 3.4–5(–6) cm. long, (2.5–)3.1–4.6 cm. wide, inner side lustrous, reticulate-veined, scattered-pubescent when young, becoming glabrous, deep rose-purple while young, brownish at maturity; styles (1.5–)2–6 mm. long; seeds pyriform to nearly spherical, 5.2–5.5 mm. in diameter, black, slightly rugose or smooth.

DISTRIBUTION: Taiwan and Fiji.

*Koelreuteria elegans* manifests an interesting and puzzling distribution, with one element in Taiwan and the other in Fiji, a discontinuity of 7200 km. without a known intermediate station. The existence of a

<sup>5</sup> Recently, through a reliable source, I learned of the existence of *K. bipinnata* at La Mortola, a garden near Ventimiglia, Italy.



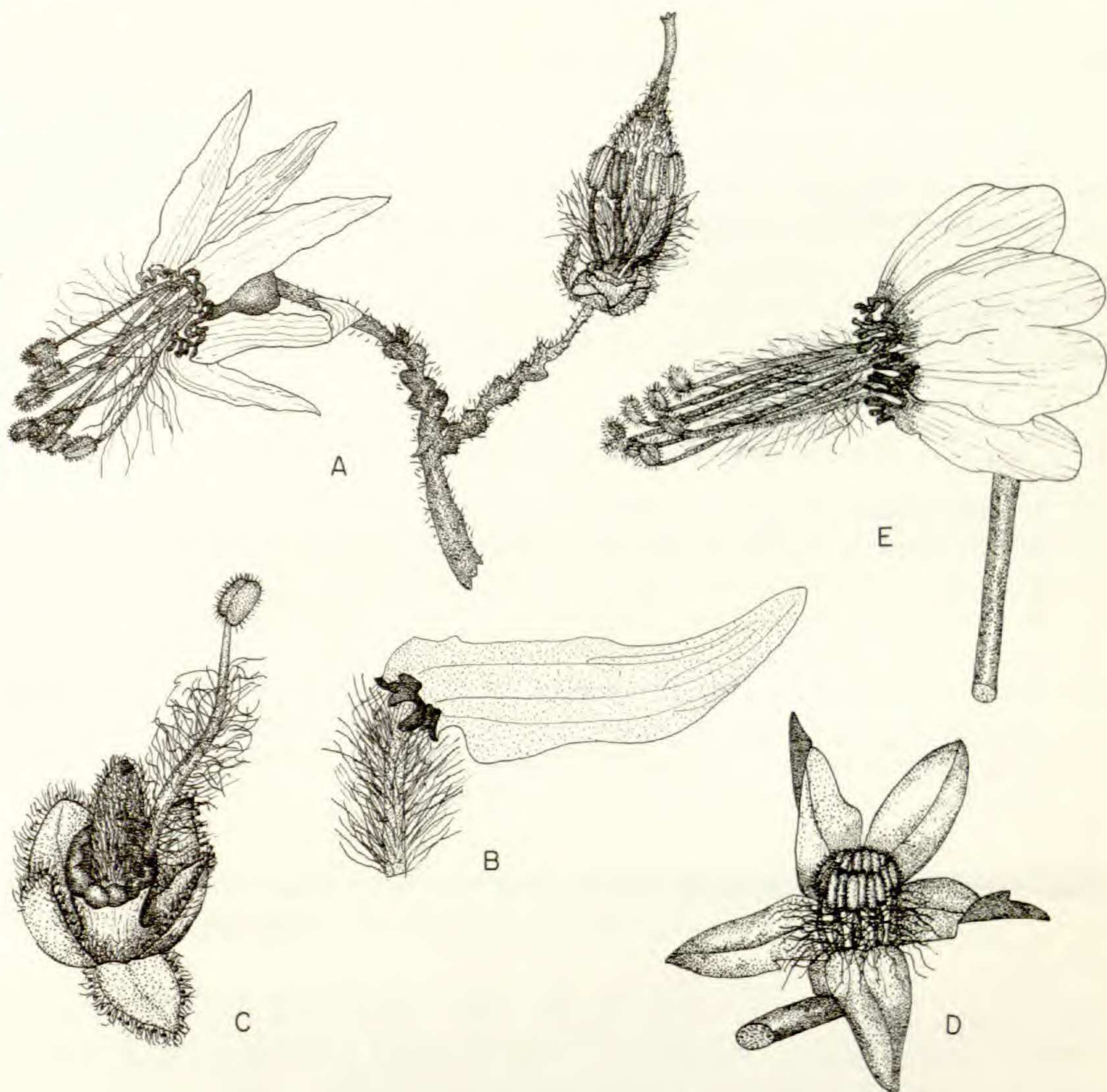


FIGURE 13. A–D, *Koelreuteria elegans* subsp. *formosana*: A, staminate flower (left) and pistillate flower (right) on ultimate branch of inflorescence,  $\times 5$ ; B, corolla lobe (dorsal side), showing the villous claw and limb with basal appendages,  $\times 10$ ; C, staminate flower, showing ciliate-glandular calyx lobes, disc on raised androgynophore, and stamen,  $\times 5$ ; D, staminate flower, showing whorl of 8 stamens which later become declinate,  $\times 5$ ; E, *Koelreuteria elegans* subsp. *elegans*, showing the broader obtuse corolla lobes and longer filaments,  $\times 5$ .

species of *Koelreuteria* on Fiji was first confirmed by Smith in 1942, on the basis of recent collections, although sometime later, in 1952, Smith recognized that Seemann had collected the plant as early as 1860 on Vanua Levu. Already, Smith (1950) had presented convincing evidence that from "the size and habitat of these trees one must suppose that they are indigenous, although the record causes an extraordinary extension of the known range of *Koelreuteria*, otherwise limited to eastern Asia and Formosa." Later, Smith (1955) listed *Koelreuteria* among 101 genera of flowering plants found primarily in Indo-Malaysia and eastern Asia, with distributions terminating in Fiji as the easternmost limit. Although Fiji is rich in species endemics, represented by about 70 per cent of the flora, *K. elegans* is not one of them.



In spite of the wide geographic disparity, the two disjunct elements of *Koelreuteria elegans* are closely related. In their general *facies*, they are more alike than they are different, for although they differ consistently in minor details of the flowers and leaves, they do not differ significantly as to pollen morphology (see Dr. Nowicke's section on pollen morphology). Taxonomically, these geographically disjunct elements are treated at the subspecific level, a course which tends to emphasize their biologic affinities more fully than if they were treated separately as species. Intensive field study, no doubt, would help to clarify this point.

#### KEY TO THE SUBSPECIES OF KOELREUTERIA ELEGANS

- A. Leaflets entire or sparsely serrate; petiolules 1–2.5(–3) mm. long; petals usually 4 or 5, rarely 6, obtuse to rounded, 5.5–7 mm. long, 2.7–3.5 mm. wide, claw 2.5–5 mm. long, up to twice as long as the calyx lobes, densely villous; filaments 8–10.1 mm. long; styles 4.5–7.5 mm. long. Fiji. . . . . 3a. subsp. *elegans*.
- A. Leaflets often rather coarsely serrate; petiolules 4–5(–10) mm. long; petals usually 5 or 4, acute, 6–7 mm. long, 1.5–2.5 mm. wide, claw ca. 2 mm. long, slightly longer than the calyx lobes, sparsely villous; filaments 4.5–6 mm. long; styles 3–4(–5) mm. long. Taiwan. . . . . 3b. subsp. *formosana*.

#### 3a. *Koelreuteria elegans* (Seem.) A. C. Sm. subsp. *elegans*.

FIGURES 6, 7, 13E–15.

*Melia*(?) *elegans* Seem. Fl. Vit. 36. 1865. HOLOTYPE: *Seemann* 64 (K); isotype (GH).

*Koelreuteria elegans* (Seem.) A. C. Sm. in Contr. U. S. Natl. Herb. 30: 518. 1952; Parham, Pl. Fiji Islands 174. 1964.

*Koelreuteria formosana* sensu A. C. Sm. in Sargentia 1: 55. 1942; non Hayata, 1913.

*Koelreuteria vitiensis* A. C. Sm. in Jour. Arnold Arb. 31: 299. 1950. HOLOTYPE: *Smith* 4389 (A); isotypes (A, BISH, L, NY, P, US).

Leaflets 5.5–9.2 cm. long, 1.3–3 cm. wide, entire or sparsely serrate, acuminate to caudate, rarely acute (supernumerary leaflets like those in subsp. *formosana* absent); petiolules 1–2.5(–3) mm. long; petals usually 4 or 5, rarely 6, obtuse to rounded, 5.5–7 mm. long, 2.7–3.5 mm. wide, claw 2.5–5 mm. long, up to twice as long as the calyx lobes, densely villous; filaments 8–10.1 mm. long; styles 4.5–7.5 mm. long.

DISTRIBUTION. Fiji. Known to occur only on the two main islands of Vanua Levu and Viti Levu, where it flowers from the end of March to about the first of May. Fruiting occurs from the end of May to mid-July.

Various habitats have been recorded, including dry secondary forest used as pasture, rocky soils on ridges in open forest, clearings in low altitude forest edge, dry hillsides, slopes of escarpment, hillside thickets, and montane forest. It occurs at altitudes from about 350 m. to about 900 m.



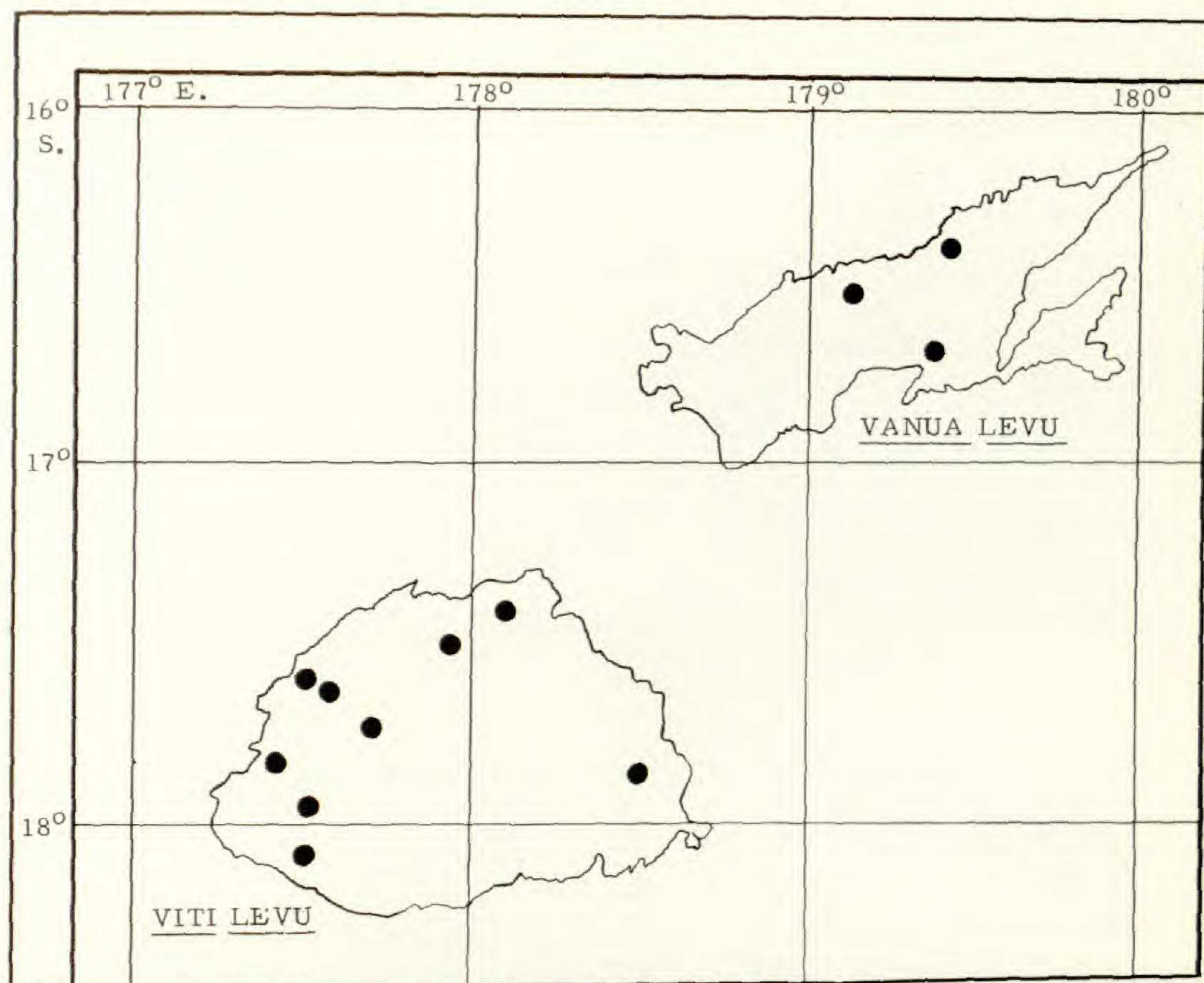


FIGURE 14. Distribution map of *Koelreuteria elegans* subsp. *elegans*.

REPRESENTATIVE SPECIMENS. **Fiji.** VANUA LEVU: above Saivon Village, Macuata [16.36S, 179.09E], *Berry* 24 (SUVA); Korotari, Macuata Prov., *Howard* 382 (SUVA); Drawa, Cakaudrove (Thakaundrove) [16.40S, 179.25E], (*Kurovoli*) *Fiji Dept. Agr.* 14327 (BISH, K, NA, SUVA); Macuata coast, *Seemann* 64 (K, holotype; isotype, GH); Mathuata, so. slopes of Mt. Numbuiloa, east of Lambasa [16.24S, 179.26E], *A. C. Smith* 6429 (A, L, S, SUVA, US). VITI LEVU: Ra, vicinity of Rewasa, near Vaileka [17.24S, 178.11E], *Degener* 15435 (A, BISH, BM, K, L, MO, NY, S, UC, US, W); Nadarivatu, trail around escarpment back of government station [17.39S, 177.35E], *Gillespie* 4181 (BISH); Mts. near Lautoka [17.37S, 177.28E], *Greenwood* 450 (K); Tholo North, below Nadarivatu, *Greenwood* 450A (A, NY, PH, UC, US); Naloto Range, Mba Prov. [17.43S, 177.44E], (*Koroiveibau & Qoro*) *Fiji Dept. Agr.* 14778 (BISH, K); Vaniyasi (Nadi), Mba Prov. [17.49S, 177.27E], (*Labaliba*) *Fiji Dept. Agr.* 2359 (SUVA); Singatoka Dist., head of Sovi Creek, *W. Parham* 4 (K); Raskulu, near Kalavokoro, Nokonoko Dist., *H. B. R. Parham* 250 (BM); King's Road [17.50S, 178.30E], *B. E. Parham* 1213 (A, SUVA); Na Coco Levu, near Singatoka, Prov. Nadroga [18.11S, 177.31E], *W. L. Parham & H. B. R. Parham* 301 (K); Nubulekaleka, Mba Prov., (*Qoro*) *Fiji Dept. Agr.* 14725 (SUVA); Nadroga & Navosa, Nabosewale, vicinity of Nadrau [17.43S, 177.57E], (*Ranamu*) *Fiji Dept. For.* 1171 (BISH, SUVA); Nadroga & Navosa, Tovua, Nabutautau [17.47S, 117.55E], (*Ranamu*) *Fiji Dept. For.* 1191 (BISH, NA, SUVA); slopes of Mt. Nairoso, eastern flank of Mt. Evans Range, Mba Prov. [17.39S, 177.35E], *A. C. Smith* 4389 (A, BISH, L, NY, P, US); Wainabuka valley, Nadarivatu [17.50S, 178.21E], *Vaughan* 3437 (BM, K, US).





FIGURE 15. *Koelreuteria elegans* subsp. *elegans*: habit ((*Ranamu*) *Fiji Dept. For.* 1171), capsules and seed ((*Ranamu*) *Fiji Dept. For.* 1185), all  $\times \frac{1}{4}$ .

The original material collected by Seemann was sterile. His notes (1865) referred to "a tree 24 feet high, having somewhat the habit of *M.* [*Melia*] *Azedarach*" and stated that while he was collecting his specimens, "the tree was just beginning to make new leaf, and had no flowers." Presumably the trees in Fiji are nearly leafless at the end of the dry season, and new growth was just beginning when Seemann visited the Mathuata coast of Vanua Levu during October of 1860.

As to the occurrence of *Koelreuteria elegans* subsp. *elegans* on Fiji, Smith (1950) noted the following: "In the Mt. Evans Range of north-western Viti Levu, this tree is one of the most striking components of the vegetation during its short flowering season, which lasts for only about two weeks, in May or early June. From the high ridges one may observe large individuals, spectacularly covered with bright yellow flowers, in the forest on the inaccessible slopes."



The Fijian subsp. *elegans* differs from subsp. *formosana* in having leaflets tending to be entire or sparsely serrate, smaller, and usually less numerous, with shorter petiolules, larger and obtuse petals, and the claw, filaments, and style all longer than in subsp. *formosana* (cf. TABLE 2).

TABLE 2. Characters distinguishing *K. elegans* subsp. *formosana* from subsp. *elegans*.

CHARACTER	SUBSP. <i>formosana</i>	SUBSP. <i>elegans</i>
LEAFLETS	(4.5-)6-10 cm. long, 1.8-3(-4.2) cm. wide; average 13.5 leaflets	5.5-9.2 cm. long, 1.3-3 cm. wide; average 11.8 leaflets
PETIOLULES	4-5(-10) mm. long	1-2.5(-3) mm. long
PETALS	5 or 4; 6-7 mm. long, 1.5-2.5 mm. wide, acute	4 or 5, rarely 6; 5.5-7 mm. long, 2.7-3.5 mm. wide, obtuse
CLAW	ca. 2 mm. long	2.5-5 mm. long
FILAMENTS	4.5-6 mm. long	8-10.1 mm. long
STYLES	3-4(-5) mm. long	4.5-7.5 mm. long

The pollen with irregularly striate ectexine appears to be the most distinctive among the members of the genus examined by Dr. Nowicke (see section on pollen morphology), although it must be pointed out that the examination was based upon only one collection.

VERNACULAR NAMES. *Towiwi*, Mba Prov. (*W. Parham* 4); *Tatage*, Vanua Levu (*Berry* 24); *Wi Wi*, Nandronga Prov., Viti Levu (*H. B. R. Parham* 250); *Lomblomba*, Ra dialect (*Degener* 15435); *Manawi* (*Monawi*), Tailevu Prov., Viti Levu (*B. E. Parham* 1213).

USES. The Fijians use *Koelreuteria elegans* subsp. *elegans* in various ways. The Kai Viti make *manawi* (also spelled *monawi*), used as hair dye, from the leaves (*W. Parham* 4). Degener reports that a black dye is made by boiling the leaves and pouring the liquid over the hair (*Degener* 15455). It is interesting to note the similar use of the leaves for a black dye in both Fiji and China. The tree is also sometimes used for timber ((*Ranamu*) *Fiji Dept. For.* 1171, 1185).

GARDENS. *Koelreuteria elegans* subsp. *elegans* is occasionally cultivated in Fiji. In 1974, seeds of the Fijian plant were distributed to botanical gardens in California, the Gulf Coast, and Florida.



- ✓ 3b. *Koelreuteria elegans* subsp. *formosana* (Hayata) F. G. Meyer, comb. nov. FIGURES 13A–D, 16.

*Koelreuteria formosana* Hayata, Icon. Pl. Formosan. 3: 64, 65. pl. XIII. 1913; Ito, Ill. Fl. Formosa 566. fig. 564. 1927; Sasaki in Trans. Nat. Soc. Formosa 19: 410. 1929; Radlk. in Engler, Pflanzenr. IV. 165: 1334. 1933. HOLOTYPE: *Kawakami & Mori 1736* (TAIF; photos, A, NA, UC, US).

*Koelreuteria bipinnata* sensu Henry in Trans. Asiatic Soc. Japan 24(suppl.): 128. 1896; sensu Matsumura & Hayata in Jour. Coll. Sci. Imp. Univ. Tokyo 22: 94. 1906; non Franchet, 1886.

*Koelreuteria henryi* Dümmer in Gard. Chron. 3rd ser. 52: 148. 1912; Elwes & Henry, Trees Gr. Brit. & Ireland 7: 1931. 1913; Radlk. in Engler, Pflanzenr. IV. 165: 1332. 1933. HOLOTYPE: *Henry 1594* (K); isotype (A).

Leaflets (4.5–)6–10.2 cm. long, 1.8–3(–4.2) cm. wide, often rather coarsely serrate, long-acuminate to caudate (supernumerary small leaflets occasionally occur at the proximal end of the rachis); petiolules 4–5(–10) mm. long; petals usually 5 or 4, acute, 6–7 mm. long, 1.5–2.5 mm. wide, claw ca. 2 mm. long, slightly longer than the calyx lobes, sparsely villous; filaments 4.5–6 mm. long; styles 3–4(–5) mm. long;  $2n = 22$  (Bowden, 1945).

DISTRIBUTION. Taiwan; also cultivated in gardens. *Koelreuteria elegans* subsp. *formosana* is apparently fairly widespread in Taiwan; however, little is known about the abundance and altitudinal range of this taxon owing primarily to a paucity of herbarium material with good data. Reputedly this is a tree of low elevations, although none of the material at my disposal mentions altitude. Flowering in September and October; fruiting in November.

REPRESENTATIVE SPECIMENS. Taiwan. Bankinsing Mts., *Henry 1594* (K, holotype of *K. henryi*; isotype, A); Nanto Hokuzanko, *Ito 15815* (TAIF); Tappanzen, Toyen [24.50N, 121.21E], *Kanahira & Sasaki s.n.* (A); Mt. Kaku-ban [24.50N, 121.21E], *Kanahira & Sasaki s.n.* (TAIF); Tappansha, Kagi, *Kawakami & Mori 1736* (TAIF, holotype; photos, A, NA, UC, US); Cuntin, Hunchuen, *Keng s.n.* (A, E, US); Paiwan, *Matuda 072082* (TAI); Kaohsiung, *I. Sasaki s.n.* (TI); Taihoku [24.50N, 121.21E], *I. Sasaki s.n.* (TAI); Saisho Kaurashi [23.11N, 120.17E], *J. Sasaki s.n.* (TAIF); upper Pinan River, Prov. Pinan, *E. H. Wilson 11145* (A, K); Lian-Hwa-Chih, Nan-Tou (as seeds), *NA 35210* (NA); Chungpu, Chia-yi (as seeds), *NA 35211* (NA); Tai-ma-lee, Tai-tung (as seeds), *NA 35212* (NA); Tai-chung City (as seeds), *NA 35209* (NA).

CULTIVATED. Africa: Egypt. Agricultural Museum garden, Dokko, Giza, *Mahdi s.n.* (CAI, NA); Faculty of Agriculture garden, Giza, *Drar s.n.* (CAI, NA). Rhodesia. Grove Farm on Umwindsi River, Goromonzi Dist., *Biegel 4231* (NA). Australia. QUEENSLAND: Hamilton, Brisbane, in ground of Butter Marketing Board, *L. P. King s.n.* (K). Asia: Taiwan. Campus, National Taiwan University, Taipei, *Keng s.n.* (TAI); Taihoku [Taipei] cult., *I. Sasaki s.n.* (TAI); First Government Exp. Farm, *Sekyo-Sai 072081* (TAI). North America: U.S.A. ALABAMA: Tom Dodd Nursery, Semmes, Mobile Co., *Meyer & Mazzeo 11145* (NA). CALIFORNIA: Upper Orpet Park, *Broder s.n.* (NA); Hugh Evans' place, Santa Monica, *Eastwood s.n.* (A); West Los Angeles, *Epling s.n.* (CAS); Los Angeles State & County Arboretum, *Jativa 2265, 2267* (NA); University Arboretum,



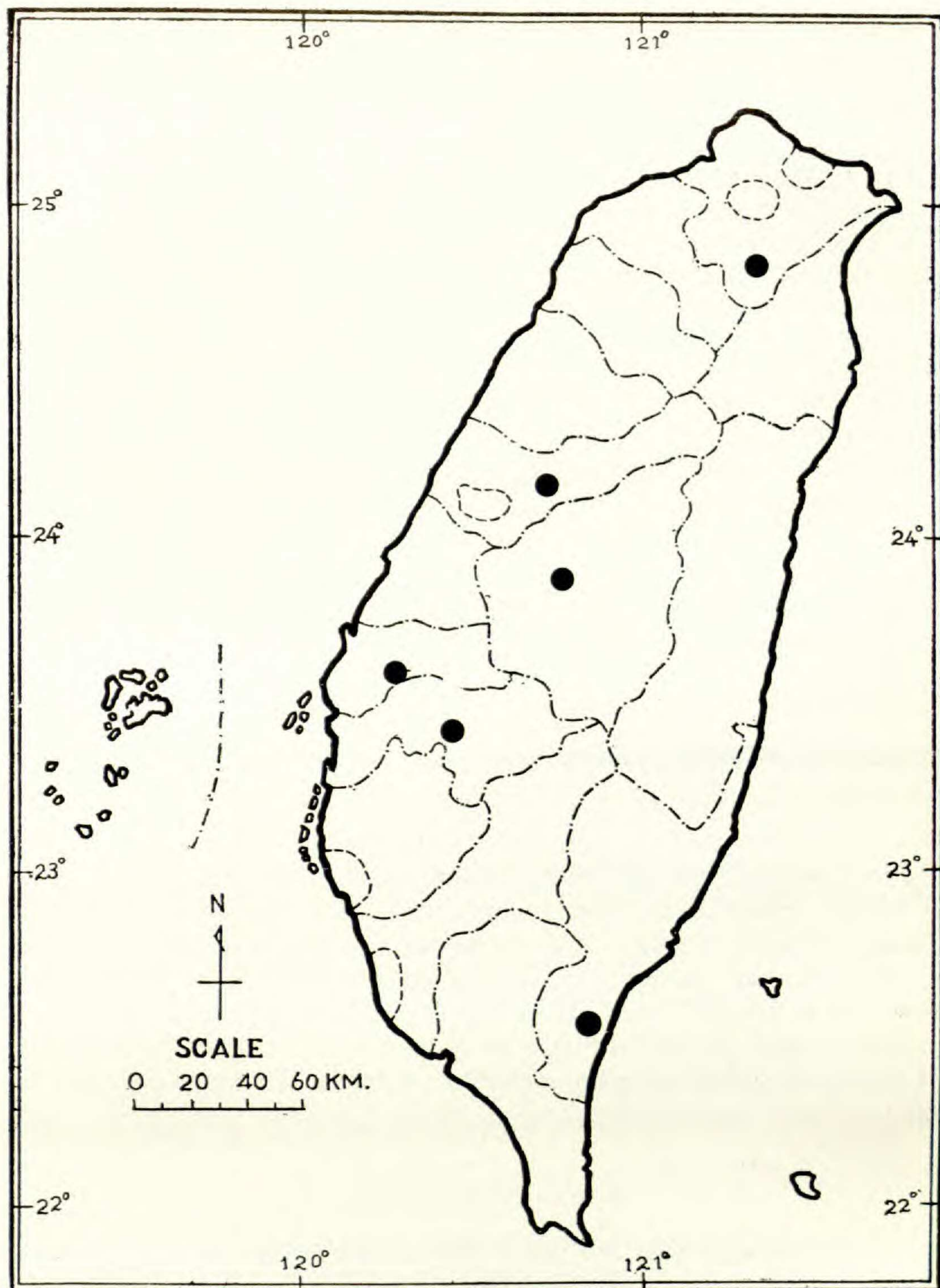


FIGURE 16. Distribution map of *Koelreuteria elegans* subsp. *formosana*.

Davis, *McClintock* s.n. (CAS, NA); 1111 Mission Ridge Road, Santa Barbara, *Moran* 2599 (SBBG); University of California campus, Davis, *McClintock & Leiser* s.n. (CAS). FLORIDA: 10400 Old Cutler Road, Coconut Grove, *Avery* 1035 (NA); Captiva Island, Lee County, *Brumbach* 6029 (A); Fairchild Tropical Garden, Coconut Grove (P. I. 41679), *Gillis* 8547 (A, CAS, NA, USF); U. S. Dept. Agr. Plant Introduction Station, Coconut Grove (P. I. 41679), *Gillis* 11115, 11141 (CAS, NA); City Cemetery, Miami, Dade Co., *Korsakoff* s.n. (NA);



20 Fourteenth Ave., South Naples, *F. C. Lee s.n.* (A); Hort. ex H. Guy, Winter Haven, *Mazzeo 2383* (A, NA); The Wilmat, University of Florida, Gainesville, Alachua Co., *Meyer & Mazzeo 14220* (NA); Hort. ex W. Paul Philips, 316 E. Church St., Orlando, *collector undesignated* (A); roadside tree near my home, Altamonte Springs, Seminole Co., *Schallert 489* (BM, P, S, USF). HAWAII: Vineyard St. Nursery, Honolulu, *Forbes s.n.* (BISH); Lyon Arboretum, *Herbst 641* (BISH); Foster Gardens, Honolulu, *Neal s.n.* (BISH). LOUISIANA: Hort. ex 104 W. William David Pkwy., Metairie, *Painter s.n.* (USF); Hort. ex Prytania St., corner Dufossat, New Orleans, *Ewan 22185* (NA); arboretum, University of Southwestern Louisiana, Lafayette, *Solymosy SC01109702* (NA). MISSISSIPPI: Poplarville, *Rogers 8680* (NA). TEXAS: campus of Texas A & M University, Brazos Co., *Fryxell 1215* (US); Corpus Christi, *F. G. Meyer s.n.* (NA, photo); Rice Institute Campus, Houston, *Traverse 884, 1725* (MO); near corner of Gramercy and Stella Link, Houston, Harris Co., *Traverse 1724* (GH). West Indies: Cuba. Harvard Tropical Garden, Soledad, Cienfuegos, Prov. Santa Clara, *Jack 8347* (A, NY, US). Europe: Italy. Stazione Sperimentale di Floricoltura, San Remo, *collector undesignated* (K). England. Royal Botanic Gardens, Kew, *Bean s.n.* (K).

*Koelreuteria elegans* subsp. *formosana* differs from the Fijian subsp. *elegans* principally in the flowers with narrower acute petals, the filaments less villous and distinctly shorter, and the larger leaflets often more coarsely serrate than in subsp. *elegans* (see TABLE 2).

VERNACULAR NAMES. *Taiwan mokugenji*; *Taiwan Sendanbotaizgu* (*Martuda 072082*).

GARDENS. The earliest recorded introduction of *Koelreuteria elegans* subsp. *formosana* into the United States dates from an introduction by the United States Department of Agriculture (P.I. 41679) in 1915 from Taihoku [Taipei], Taiwan. This attractive tree is now grown in Hawaii, in California, and on the Gulf Coast; in Florida it has escaped from cultivation in certain areas. Flowering occurs from the end of September through October. During anthesis, the flowers emit a mild orange-blossom-like fragrance, which is highly attractive to bees and other pollinating insects.

#### EXCLUDED NAMES

*Kölreutera mulluginoides* Murray in Nov. Comm. Soc. Sci. Gott. 3: 67. tab. II. pl. 2. 1773 = *Gisekia pharnacioides* L.

*Koelreutera hygrometrica* Hedwig, Fundam. Muscor. 2: 95. 1782 = *Funnaria hygrometrica* Hedwig.

*Koelreutera* Schreb. Gen. 2: 731. 1791.

*Koelreuteria arborea* Blanco, Fl. Filip. (ed. 3) 4: (Nov. App.) 52. 1880 = *Guioa perrottetii* (Bl.) Radlk.

*Koelreuteria arborescens* Pierre nom. in hb. = *Arfeuillea arborescens* Pierre.

*Koelreuteria completa* Medic. in Hist. & Comm. Acad. Elect. Sci. Theod. Palat. VI. 407. 1790 = *Marsdenia erecta* R. Br?



- Koelreuteria edulis* Blanco, Fl. Filip. (ed. 2) 202. 1845; (ed. 3) 4: (Nov. App.) 52. *pl.* 110. 1880 = *Otophora fruticosa* (Roxb.) Bl.
- Koelreuteria incompleta* Medic. in Hist. & Comm. Acad. Elect. Sci. Theod. Palat. VI. 407. 1790 = *Marsdenia erecta* R. Br?
- Koelreuteria procumbens* Medic. Bot. Beobacht. 22. (1782) 1783 = *Marsdenia erecta* R. Br?
- Koelreuteria triphylla* nom. in hb. P-Jussieu (n. 11345) = *Urvillea ulmacea* Kunth.
- Koelreuteria minor* Hemsley in Hooker's Icon. Pl. 27: *pl.* 2642. 1900; non *Koelreuteria*.

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